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AN ASSESSMENT OF THE IMPACT OF COMBINED SEWER OVERFLOWS AT PEORIA ON THE WATERS OF THE ILLINOIS WATERWAY

by the Staff of the Water Quality Section

Prepared for the City of Peoria

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by the Staff of the Water Quality Section,
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INTRODUCTION

Virtually every municipality located along the banks of the Illinois River is served by combined sewers. These sewers, when originally placed, were designed solely to convey surface water runoff from residential and commercial properties with ultimate discharge in the river. They were not intended to function as conduits for the transport of wastewater. With the introduction of in-house plumbing it became common practice to connect "property sewers" to the existing drainage system. As communities expanded, separate sanitary sewers were constructed but they too were connected to the surface water drainage system. Thus the system originally conceived for solely handling urban drainage became a dual purpose utility, conveying a combination of surface water runoff and wastewater.

During the past 40 to 50 years efforts have been made to relieve wastewater discharges to the original drainage system by intercepting existing sanitary sewers and conveying the flow of wastewater to sewage treatment facilities. Connections of newly constructed sanitary sewers to the old drainage system have been prohibited, and in addition a considerable effort has been made to minimize the discharge of wastewater conveyed by the old drainage system into the river.

The City of Peoria is served by a combined sewer system in addition to a well-conceived separate sanitary sewer system. The combined system consists of about 123 miles of conduit serving 2950 acres. The area served includes all of the city below the bluffs and most of the older sections of the city commonly known as the "east" and "west" bluffs. During storm events discharges from the system to the river occur at 20 locations along about 4 miles of the riverfront. These outfalls are listed in table 1 and their locations are depicted in figures 1 and 2.

Following the construction of wastewater treatment facilities and the riverfront interceptor by the GPSD, efforts were made to minimize the discharge of wastewater into the river from the 20 combined sewer outfalls. This was accomplished by the installation of regulators in the combined sewers upstream of the riverfront interceptor. The regulators, 23 in number, were principally designed to divert all dry weather flow in the combined sewers to the interceptor. In actual operation the regulators are adjusted to divert flows in the combined sewers into the interceptor in excess of dry weather flow. The interceptor then conveys the wastewater to the treatment facilities. Flows in the combined system in excess of the capacity of the interceptor or the regulators overflow into the river. It is the impact of these combined

Table 1. Peoria Combined Sewer Locations and Characteristics

Overflow Designation			Corps of		Peak Flow Rate (cfs)*		Degree of Submergence		
					For Rainfalls of		During Flat Pool Stage		
Water Survey	Randolph s Assoc.	Street Name	Engineer River Mile	Sewer Size (in.)	0.37 in/hr	1.56 in/hr	Full	Partial	Free
1	1	Caroline	163.82	36-round	5	64	X		
2	2	Spring	163.62	60-round	21	270			X
3	3	Morgan	163.31	48 x 58 ellipse	0	36			X
4	4	Green	162.94	30 x 45 ellipse	4	48			X
5	5	Hancock	162.90	30-round	0	2			X
6	6	Eaton	162.77	60-round	8	92		X	
7	7	Fayette	162.71	42-round	22	220		X	
8	8	Hamilton	162.68	42-round	0	8		X	
9	9	Main	162.61	42-round	10	88		X	
10	10	Fulton (?)	162.50	36-round	0	4	X		
11	11	Liberty	162.43	48-round	1	8	(?)		
12	12	Harrison	162.37	20-round	1	6			X
13	13	Franklin	162.28	60-round	0	3			X
14	14	Walnut	162.21	34 x 51 ellipse	6	68			X
15	15	State	162.13	30-round	0	18	X		
16	16	Oak	162.05	48-round	8	100	X		
17	18	Cedar	161.51	72-round	44	458		X	
18	19	South	16.097	2, 48-round	6	84			X
19	20	Sanger	160.55	72-round	3	28		X	
20	21	Darst	160.12	84-round	36	430			X

* Based on preliminary estimates from Randolph S Assoc, facility planning document

(?)=Questionable or not specifically known

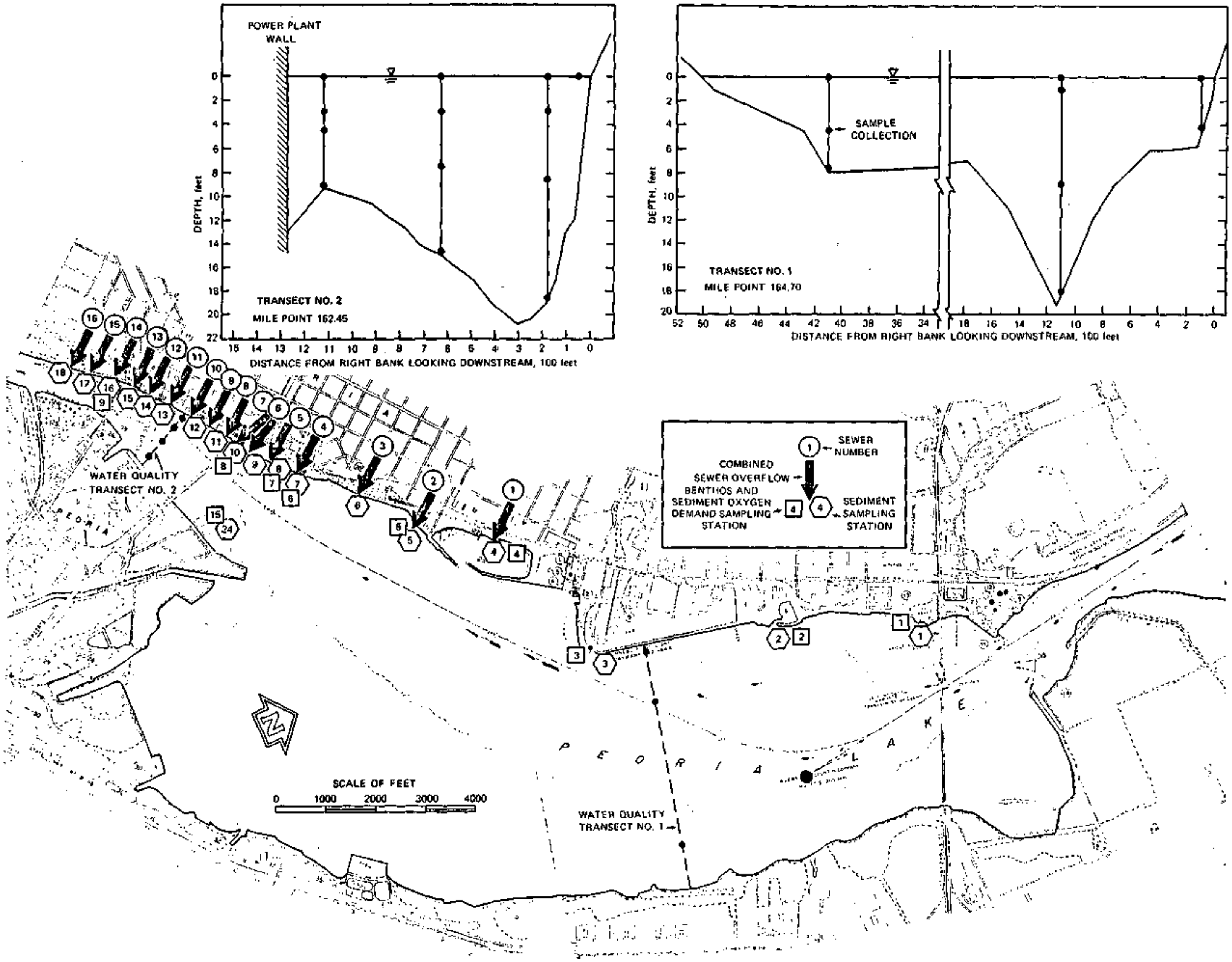


Figure 1. Combined sewer overflows and sampling locations above Cedar Street bridge

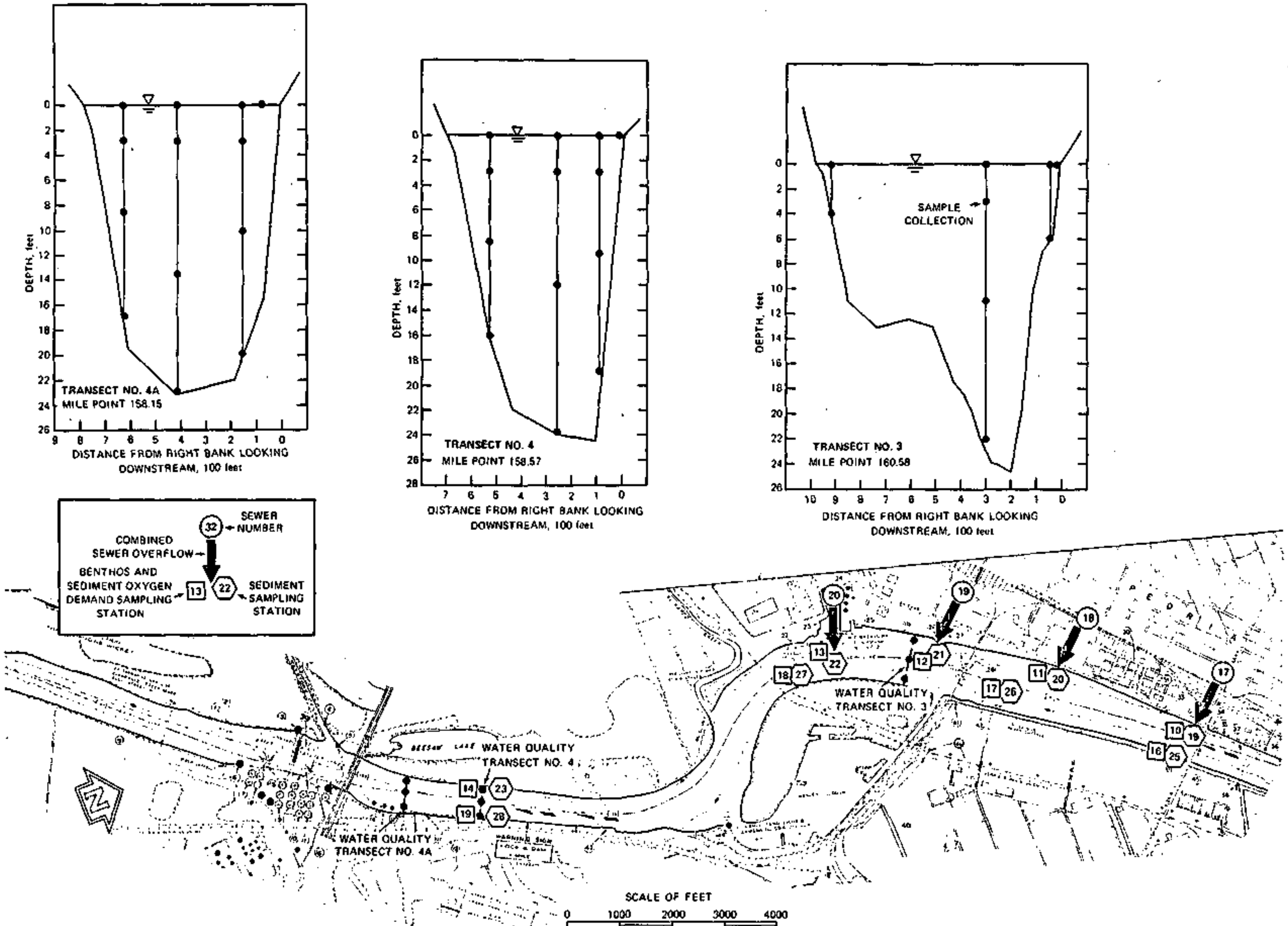


Figure 2. Combined sewer overflows and sampling locations below Cedar Street bridge

sewer overflows (a mixture of urban drainage and domestic and commercial wastewater) on the water quality of the Illinois Waterway that is the focal point of this report.

Regulatory Implications

Until about 1970 the practice of handling flows in combined sewers as described here was an acceptable procedure for most cities in Illinois. That is, if quantities of the combined sewer flow were diverted to a wastewater treatment plant, consistent with the capacity of interceptor sewers and the treatment capability of the plant, the discharge of combined sewer overflow (CSO) into a stream was permissible. This was particularly the case for Illinois communities located along major streams. The rationale was that since CSOs occurred only during periods of wet weather, when flows in the receiving stream were correspondingly higher, sufficient dilution was available to minimize adverse water quality conditions. However, stream studies designed to verify this assumption were not performed. With the passage of the Illinois Environmental Protection Act in 1970 and the Federal Water Pollution Control Act (FWPCA) in 1972, the status of CSOs was viewed from a much different perspective.

The passage of these acts and the promulgation of associated rules and regulations initiated an ambitious program for assigning use designations for national waters and identifying water quality criteria necessary to support those uses. Quality limits were imposed on all effluent discharges to those waters, and a permitting system was developed for controlling all discharges into the waters.

Although these acts stimulated the development of wide-ranging in-stream water quality standards, the major impetus for enforcement action in the water quality management plans that evolved placed principal reliance on <u>effluent standards</u> and the <u>permitting system</u>. As a minimum every wastewater effluent had to meet" certain physical, chemical, and biological standards, and the owners of the conduits conveying the discharge were required to obtain a permit within the National Pollutant Discharge Elimination System (NPDES). Within this framework the issue of the impact of CSOs at Peoria on the water quality of the river became moot. The City of Peoria was compelled to obtain an NPDES permit with the understanding that work would be undertaken to assure compliance of each CSO with applicable effluent standards.

In order to maintain grant eligibility the city proceeded in accordance with IEPA guidelines. A cost-benefit analysis was performed on the basis of level of pollutants required to be removed — not on the water quality impact.

As work progressed toward the development of a treatment solution and the costs involved became more apparent, certain questions arose: What was the impact of Peoria CSOs on the Illinois River? Would there be a significant improvement in the water quality of the river after proposed treatment was in place? What was the relationship between the cost to be imposed and the benefits to be derived? About this time (1980) the Illinois Environmental Protection Agency (IEPA) proposed a 5-year strategy for water quality management for the stated purpose of achieving "the best water quality conditions possible consistent with the social and economic needs of the State of Illinois." The proposal suggested some latitude relative to the policy of undue reliance on effluent standards as a measure of compliance. Implicit in the proposed strategy was the realization that the elements of a water quality management program must be socially acceptable.

The questions raised by the City of Peoria and the new strategy proposed by IEPA both pointed up the need for a water quality study. Arrangements were made for a site specific study designed to define the impact of CSOs at Peoria on the waters of the Illinois Waterway.

Scope and Purpose of Study

The Illinois State Water Survey (SWS) undertook the responsibility for coordinating the study, evaluating the data, and preparing the final report. Basic planning and data collection duties were divided between SWS and the city's consulting engineers, Randolph and Associates (R & A) . SWS was responsible for planning and implementing those phases of the study related to in-stream measurements and sampling, including water, sediment, and biological sampling. R & A was responsible for planning and implementing those phases of the study related to CSO measurements and sampling as well as weather monitoring. This included measuring sewer flows, collecting CSO samples, establishing rainfall gaging stations, and monitoring storm movements.

SWS had the additional assignment of planning and implementing a mixing zone study. As defined by the IEPA, the mixing zone is an area in the vicinity of a CSO outfall in which stream standards are generally not applicable. General requirements for mixing zone limits are outlined in Section 201(a) of the Illinois Pollution Control Board Rules and Regulations. The planning and organizing of the mixing zone study has been completed but no data have been collected. The details and results of this phase of the study will be presented in a separate report. Included in that report will also be the BOD-DO modelling exercise developed from this study.

The purpose of the water quality investigative phase of the study was to determine the degree to which the water quality in the Illinois River is impacted by CSOs during moderate to low river flows. Of primary interest is whether existing water quality standards are violated during such overflows, and if the bottom sediments and benthos (bottom dwelling macroorganisms) exhibit short- and/or long-term deleterious effects. In the event of non-violation of the water quality standards, evaluations were to be made to determine if detectable water quality changes occur in the river reach delineated by the Peoria lock and dam and the area directly receiving the CSO discharges.

Acknowledgments

The in-stream work required for this project was performed under the supervision and guidance of Ralph Evans, Head, Water Quality Section of the Illinois State Water Survey. Linda Johnson typed the original manuscript and prepared the camera copy. Illustrations were prepared by John Brother, Jr., William Motherway, Jr., and Vicki Stewart. The manuscript was edited by Gail Taylor.

The successful completion of the undertaking would not have been possible without the cooperation and expertise of all staff members of the Water Quality Section. Notable among these were: Thomas Butts, who directed field operations; Dave Hullinger, Dana Shackleford, and Brent Gregory, who analyzed samples; Thomas Hill, who enumerated and identified benthos; and Shundar Lin, Donald Schnepper, Davis Beuscher, Gene Brooks, V. Kothandaraman, Richard Twait, Judson Williams, and Thomas Walkowiak, who performed field measurements, collected samples, and operated boats, all under the most adverse conditions.

In addition, the patience and coordination maintained by Richard Helm of Randolph and Associates and James Dallmyer of Daily Analytical Laboratories were instrumental in overcoming problems related to stream-to-shore communications and sample distribution. And the understanding and continued interest of James Carlisle of the Greater Peoria Sanitary District and Eugene Hewitt of the City of Peoria eased the transition of financial resources to the field and laboratory operations in an expeditious and timely fashion.

To all these persons the Survey is grateful.

SAMPLING DESIGN AND DATA EVALUATION

The river sampling program has been designed to provide information on water quality during dry weather and wet weather river flows. The dry weather data provide background information for use in evaluating changes in water quality which may occur in the river during wet weather. Dry weather sampling involved river sampling only; however, wet weather sampling involved a coordinated effort between Randolph and Associates (R & A) for sewer sampling and the State Water Survey (SWS) for river sampling. The same basic river sampling program was used during both dry and wet weather situations.

River Sampling Design

River sampling involved two distinct undertakings: sampling of the water column and sampling for benthic (bottom) material. Both efforts were designed to provide a wide range of chemical, physical, and biological information useful for assessing the ecological conditions of an aquatic habitat.

Water Sampling. Water sampling was performed at four transect locations as shown in figures 1 and 2. The upper transect, located at river milepoint (MP) 164.70, is above all CSO outfalls; it was positioned to provide representative wet weather water quality data free of any CSO discharge influences. Transect 2 is located immediately above Liberty Street (MP 162.45). It was positioned principally to detect the influence of one-half of all the individual CSOs; in addition, it is located just below the terminus of lower Peoria Lake. Transect 3 is located just below Sanger Street at MP 160.58, and water quality at this location is influenced by 19 upstream CSOs. The last transect is located below all the CSOs including the Greater Peoria Sanitary District treatment plant effluent discharge. The actual sampling location in this area varied somewhat from time to time due to barge fleeting obstructions along the west bank. The cross sections depicted as transect 4 (MP 158.57) and transect 4A (MP 158.15) bracket the area sampled during various runs.

On transect 1, that transect located above all CSOs, water samples were collected at 3 locations on the horizontal. At the other three transects collections were made at 4 locations on the horizontal. The extra location on these transects is arbitrarily defined as the mixing zone sample in this report and is located as close to shore as could be reached by boat. At each of the sampling locations one to four water samples were collected on the vertical. For locations 10 feet or greater in water depth, samples were collected at the surface, 3 feet, mid-depth, and near bottom. For locations 6 to 10 feet deep collections were made at the surface, 3 feet, and near bottom. For water depths less than 6 feet, collections were made at the surface and near bottom. The mixing zone samples (near-shore) were collected only at the surface. All water sampling points for each transect are represented by "dots" in the transect sketches in figures 1 and 2. A total of 44 sampling points were maintained during sampling of the water column.

Sample collections were made every 30 minutes commensurate with the beginning and ending of significant sewer overflows. Sufficient sample containers were available to complete nine passes across the transect during a storm event. In the event of an intense storm of long duration, plans were to make seven passes (3.0 hours) per transect, wait 60 minutes before making the eighth, and delay the ninth pass until the end of the storm. However, for each storm event monitored during the course of the study, six passes proved sufficient to fully bracket the overflow period.

The guidelines established for performing the field work included:

1) Field work had to be performed between April 1 and October 31, 1982.

2) River discharge had to be equal to or less than 15,000 cubic feet per second (cfs) near Peoria.

3) Rainfall had to total 0.5 inches or greater over a 60-minute period to qualify as an official event.

4) Three storm events meeting the requirements of guideline 3 had to be sampled.

5) Time intervals between sampling periods had to be maximized to minimize the influence of the last previous events.

The parameters for which analyses or measurements were made were:

1) Dissolved oxygen	9) Suspended solids
2) pH	10) Turbidity
3) Ammonia	11) Grease
4) Cadmium	12) Oil
5) Copper	13) Fecal coliform (bacteria)
6) Lead	14) Total biochemical oxygen demand
7) Zinc	15) Carbonaceous biochemical oxygen demand
8) Temperature	

Analyses or measurements for parameters 1 through 10 were performed at all stream stations; fecal coliform, grease, and oil analyses were performed only on surface samples. Biochemical oxygen demand (BOD) analyses were limited to mid-depth samples collected during the second and last runs at the three vertical locations on transects 1 and 3 and at the center vertical on transect 4. Parameters 1 through 7 relate to chemical characteristics of the water, while parameters 8 through 12 relate to physical characteristics. Parameters 13, 14, and 15 are related to biological activity. The environmental and ecological significance of each parameter will be briefly discussed later to aid in the interpretations of the results presented in this report.

Bottom Sediment Sampling. Physical, chemical, and biological tests were used to investigate the extent and nature of the CSO impact on bottom sediments. Sediments were collected on two occasions (in July 1982 and March 1983) from 28 locations for physical and chemical laboratory analyses. The sampling locations are shown in figures 1 and 2. They include three sites upstream and one downstream of all combined sewer outfalls along the Peoria side of the river, 19 sites immediately downstream of all the outfalls except Fulton Street, and five sites along the East Peoria side. Collections were made within four days after a significant overflow period and again after an extended dry period.

The Fulton Street outfall was not included because its exact location is not known, and some doubt existed at the beginning of the study as to the exact nature of the overflow routing between Main and Fulton Streets.

The physical and chemical tests performed on the sediment samples were:

1) Percent clay	6) Cadmium
2) Percent silt	7) Copper
3) Percent sand, gravel, or rocks	8) Lead
4) Percent moisture	9) Zinc
5) Percent volatile solids	10) Grease and oil

The biological activity of the sediments was evaluated by examining the density and types of macroinvertebrates inhabiting them and monitoring the *in-situ* gross respiratory activity (sediment oxygen demand) of benthic bacteria and macroorganisms. Nineteen sites were examined for biological activity as shown in figures 1 and 2. Three locations are upstream and one downstream of all outfalls, ten are within the area directly influenced by the outfalls, and five are along the East Peoria side. The locations of these sites, along with the sediment sampling stations, are presented in table 2. Biological sampling sites within the CSO area were carefully selected to detect the influence of the full range of overflows.

At each of the 19 biological sampling stations, sediment samples were also collected for performing sediment oxygen demand (SOD) tests in the laboratory. These tests were designed to isolate the chemical and biological fractions from the total SOD and to further divide the biological fraction into carbonaceous and nitrogenous demands.

Sewer Sampling Design

Data collection relative to combined sewer water quality, combined sewer flows, and rainfall measurements was the responsibility of Randolph and Associates. Sampling of selected sewer overflows was coordinated with the river sampling performed by the State Water Survey.

CSO Quality Sampling. Since it was not practical to sample all 20 CSOs during a storm event, eight combined sewers and one storm sewer were selected as representative. These sewers and their respective estimated percentage contributions to the total overflow during an intense storm are presented in table 3. The eight CSOs represent 86.5 percent of the total overflow volume predicted to occur during a 1.56-inch rain over a 4-hour period.

Sampling was done in overflow conduit manholes. Automatic, computer controlled samplers were installed to collect samples at 10-minute intervals from the beginning to the end of significant overflows. This procedure was designed to produce sequential and discrete samples.

Each sample was analyzed for the following constituents:

1) Ammonia
2) pH
3) Cadmium
4) Copper
5) Lead
6) Zinc
7) Settleable solids
8) Volatile settleable solids
9) Suspended solids
10) 5-day biochemical oxygen demand
11) Fecal coliform

Parameters 1 through 6 relate to chemical pollutants; 7, 8, and 9 relate to physical pollutants; and 10 and 11 relate to biological pollutants.

Table 2. Sediment, Benthos and Sediment Oxygen Demand (SOD) Sampling Station Locations by Corps of Engineers Mile Points (MP)

Sampling Station Number		CSO		
Sediment	Benthos & SOD	Number	MP	Remarks
1	1	-	165.72	In Lower Peoria Lake
2	2	-	165.30	In Lower Peoria Lake
3	3	-	164.40	In Lower Peoria Lake
4	4	1	163.82	Inside Detweiler Harbor
5	5	2	163.62	Below 3rd largest CSO
6	-	3	163.61	
7	6	4	162.94	Below 11th S 12th largest CSOs
8	7	5	162.90	Below 19th largest CSO
9		6	162.77	Below 4th and 6th largest CSOs
10	8	7	162.71	
11	-	8	162.68	
12		9	162.61	
—	-	10	162.50	
13	-	11	162.43	
14	-	12	162.37	
15	-	13	162.28	
16	9	14	162.21	Below 9th largest CSO
17	-	15	162.13	
18	-	16	162.05	
19	10	17	161.51	Below 2nd largest CSO
20	11	18	160.97	Below 8th largest CSO
21	12	19	160.55	Below 12th largest CSO
22	13	20	160.12	Below largest CSO
23	14	—	158.57	
24	15	—	163.62	
25	16	--	162.13	
26	17	--	160.62	
27	18	—	160.12	
28	19	--	158.57	

Table 3. Combined Sewer Overflows
Selected for Sampling

SWS Number	Street Designation	% Volume Contribution for 1.56-inch Rain
2	Spring	13.1
6	Eaton	4.6
7	Fayette	11.0
9	Main	4.4
16	Oak	5.1
17	Cedar	22.0
18	South	4.1
20	Darst	22.2
	174 Storm	--

Sewer Flow and Rain Measuring. Sewer flow and rain measurements were done automatically and continuously using a computer telemetry network. Flow measuring devices were placed at the eight CSOs and in the 1-74 storm sewer. Three rain gages were established — one at Spring Street, a second at Peoria Fire Station No. 3, and a third at Darst Street. These three locations bracketed the area served by the CSOs. Flows for all sewers were measured every minute and then averaged for each 10-minute interval.

Sample Analyses and Data Evaluation

The analytical results for the river sampling program were produced by laboratories in three separate agencies. They were the State Water Survey laboratories in Peoria and Champaign, Randolph and Associates (R & A) laboratory, and Daily and Associates (D & A) laboratory. The distribution of river samples among the three agencies is shown in table 4. Randolph and Associates performed all the analytical work on the samples collected from the sewers.

River water samples were distributed either to Randolph and Associates or to Daily and Associates on an alternate pass basis for each transect; i.e., each laboratory received all samples collected on either the odd or even passes. Also, duplicate samples were collected for 5 percent of the total samples for quality control purposes.

As mentioned earlier the State Water Survey was also responsible for assembling, tabulating, and analyzing all data and compiling the results. For this purpose the following objectives were major considerations:

1) Determine the various constituent loads emanating from combined sewer overflows.

Table 4. River Sample Laboratory Distribution Schedule

Sample Type	Parameter	Percentage Analyzed by Laboratory: State Water Survey Champaign	Peoria	R&A	D&A
Water	pH	0	100	0	0
	Turbidity	0	100	0	0
	Ammonia	0	100	0	0
	Suspended Solids	0	100	0	0
	Total BOD	0	100	0	0
	Carbonaceous BOD	0	100	0	0
	Fecal Coliform	0	0	50	50
	Grease & Oil	0	0	50	50
	Copper	0	0	50	50
	Cadmium	0	0	50	50
	Lead	0	0	50	50
	Zinc	0	0	50	50
Sediment	Percent Moisture	0	100	0	0
	Percent Volatile	0	100	0	0
	Particle Size	100	0	0	0
	Benthos	0	100	0	0
	Grease & Oil	0	0	50	50
	Copper	0	0	50	50
	Cadmium	0	0	50	50
	Lead	0	0	50	50
	Zinc	0	0	50	50

2) Determine the degree to which the constituents of combined sewer overflow impact the water quality of the river.

3) Ascertain whether or not the water quality within the reach of the river directly receiving combined sewer overflows exhibits significant variability within this reach or is significantly different, overall, from that not receiving any overflow.

4) Determine the areal extent and degree of compliance and/or noncompliance of water quality standards applicable to the river during overflow periods.

5) Determine the probable long-term detrimental effects of combined sewer overflows on river littoral sediments and benthos substrates.

6) Examine the feasibility of developing a reliable river water quality model for use in predicting the effects of combined sewer overflows on river water quality during rainfalls of varying intensities and durations (not included as part of this report).

RESULTS AND DISCUSSION

The river sampling data and results will first be presented and discussed, after which the sewer sampling data and related rainfall information will be presented and discussed. When a water quality parameter is first addressed, a brief review of its environmental and ecological significance will be given. When appropriate, a discussion will be presented relative to the fulfillment of the objectives.

Considerable reliance has been placed on the use of tables for summarizing the data. Reference is made in these tables to average, maximum, and minimum values observed at sites L, C, R, and M. The locations of these sites looking downstream are:

L - left bank (East Peoria side)

C - center (channel of river)

R - right bank (Peoria side)

M - mixing zone (near-shore Peoria side)

River Water Sampling

The dates of sampling are presented in table 5 along with general information relative to sewer and river hydrologic and hydraulic conditions. About 535 sewer samples were collected on which 6384 separate analytical analyses were performed. For the river work, approximately 11,450 field and/or laboratory analyses were performed on 1040 samples.

Generally the criteria established for sampling were achieved. The data presented in table 5 show that river sampling runs were completed on three overflow dates in 1982 (June 28, August 24, and September 17) and on two dry weather dates (June 25 and September 14). During this time the flow of the river varied from 6315 cfs to 10,335 cfs. The sampling of CSOs was performed on seven occasions. In addition to the sampling during the three river sampling events, additional sampling of the CSOs was performed on July 7, July 18, August 7, and November 1.

The in-stream sampling during dry weather provided excellent background information since both runs were completed only three days prior to overflow sampling events. The timeliness of these runs minimized seasonal and river hydraulic variations when comparing the dry and wet weather situations. The September 17 rainfall intensity fell somewhat short of the requirement for an official event of 0.5 inches per hour over a 1-hour period. However, the 30-minute average intensity for the three rain gages was 0.51 inches per hour and sewer overflows persisted for 190 minutes. Consequently, after the characteristics of this event were reviewed with IEPA it was deemed acceptable.

The rainfall intensities varied considerably between in-stream sampling runs. The values of 1.44, 1.09, and 0.33 in./hr provided a wide range of

Table 5. River and Sewer Sampling Dates and Generalized Hydrologic and Hydraulic Information

	River	Rainfall		Duration (min)*		Samples	
Date	Flow (ft^3/sec)	Maximum 1-hr rain (in.)	Total (in.)	Sewer Overflow	River Sampling	Discrete Sewer	River Points
6/25/82	8,540	0	0	0	30	0	86
6/28	10,335	1.09	1.16	136	150	50	253
7/07	15,150	0.84	0.88	126	0	51	0
7/18	15,600	0.52	1.34	318	0	135	0
8/07	10,975	0.74	0.87	156	0	81	0
8/24	8,175	1.44	2.08	198	150	80	273
9/14	6,315	o	0	0	30	0	88
9/17	6,600	0.33	0.64	218	150	101	288
11/01	—	0.93	1.57	264	0	34	0

* Excluding 1-74 sewer

conditions for which evaluations and comparisons could be made. Also, the three overflow events for which river samples were collected occurred after one to three weeks of dryness, which allowed solids and other materials to accumulate within the combined sewer system. This tended to maximize the potential impact of the overflow discharges on the river waters.

Dissolved Oxygen. Dissolved oxygen (DO) is probably the most widely used and the single most important parameter used to evaluate the ecological and/or pollutional status of surface waters. It is particularly important for measuring the effects of organic pollutants normally found in sewage. DO measurements coupled with temperature measurements can provide valuable ecological information relative to a large number of aquatic factors such as primary productivity, benthos conditions, waste assimilative capacity, and aquatic wildlife.

Dissolved oxygen is necessary for the respiratory needs of most desirable aquatic organisms, and its concentration is often the limiting factor in the spatial distribution of the inhabitants of an aquatic community. For example, a bass will forsake an optimal temperature stratum if it is low in DO and will seek a DO level of 5 mg/l or greater regardless of temperature. A total lack of DO results in anoxic conditions commonly referred to as septic.

The Illinois Pollution Control Board (PCB) has established minimum standards for DO concentrations in surface waters. Section 302.206 of the PCB Rules and Regulations stipulates that for water quality for general use (applicable to the Illinois River at Peoria) the DO shall not be less than 6.0 mg/l during at least 16 hours of a 24 hour period, nor less than 5.0 mg/l at any time.

The results of DO measurements performed in the field at the time of stream sampling are shown in table 6. Average and minimum values are included for dry weather and wet weather conditions. During the dry weather period on June 25 the DO concentrations at all transects measured were within a narrow range of about 6 to 7 mg/l. Equipment failure at transect 3 precluded any recording of values. However on September 14 the range of values extended from about 6 to 11 mg/l. Transects 1 and 2 exhibited the higher values which probably reflect the influence of photosynthetic activity in Lake Peoria. In general DO concentrations decreased with downstream movement.

Table 6. Dissolved Oxygen Concentration by Date and Location
(L = Left Bank; C = Center; R = Right Bank;
M = Mixing Zone Looking Downstream)

		Dissolved Oxygen Concentration (mg/l)							
	Transect	Average				Minimum			
Date	Number	L	C	R	M	L	C	R	M
					Dry Weather				
6/25	1	6.76	6.78	7.25	—	6.55	6.4	6.90	—
	2	6.81	6.64	6.18	6.98	5.60	6.35	5.90	6 75
	3	--	--	--	--	--	--	--	--
	4	7.01	7.04	7.03	6.80	6.65	6.90	6.85	6.80
9/14	1	9.00	8.48	11.10	—	8.10	7.80	10.80	—
	2	9.68	8.10	7.94	9.10	8.40	7.15	7.05	8.60
	3	7.88	7.44	7.63	7.50	7.80	7.30	7.30	7.30
	4	6.33	6.41	6.24	6.50	6.00	6.10	6.00	6.50
					Wet Weather				
6/28	1	6.31	6.43	7.33	--	5.80	5.90	7.10	—
	2	9.27	6.74	6.87	7.08	8.10	6.20	6.20	6.50
	3	8.61	6.93	6.77	6.98	8.50	6.20	6.10	6.80
	4	6.81	6.54	6.43	6.53	6.50	6.40	6.00	6.25
8/24	1	6.93	6.43	6.84	—	6.50	6.10	6.50	—
	2	7.54	7.20	7.11	7.39	7.10	6.85	6 50	7 20
	3	7.70	7.35	7.27	7.63	6.60	6.40	6.35	7.20
	4	5.38	5.48	5.54	5.75	3.10	4.90	5.10	4.90
9/17	1	8.92	8.98	10.50	--	8.60	8.17	9.00	—
	2	9.53	9.26	9.26	9.37	9.10	9.00	8.90	8.90
	3	8.70	8.87	8.56	8.48	8.60	8.50	8.30	8.30
	4	6.94	7.03	7.14	7.40	6.50	6.80	6.80	6.70

During wet weather conditions minimum concentrations of DO generally ranged from about 6 to 9 mg/l. On one occasion, for a short period of time on August 24, a minimum DO of 3.1 mg/l was recorded at transect 4. This occurred on the East Peoria side of the river. Transect 4 consistently produced the lowest average DO concentrations, with the lowest average occurring on the East Peoria side of the stream.

Many factors other than CSO discharges can contribute to the variability in DO concentrations. These include barge traffic, sampling depth, contrasting lake versus river environments, wind direction, cloud cover, overland drainage, and tributary input. Some of this variability is demonstrated in table 7, which presents the results of DO measurements for a 2-day period during the collection of bottom sediments. The spatial differences coupled with cloud cover are quite pronounced.

In 1979 during warm weather months 25 sets of DO measurements were made at 3-foot depths in the river channel at the approximate locations of the four transects. Table 8 presents the minimum and average values for the data along with the values for the 1982 data. Generally the values during 1979 were less than those observed in 1982, but on the average there was a general decrease in DO concentrations during both years between transect 3 and transect 4.

On the average the decrease in DO concentrations (in milligrams per liter) between transect 3 and transect 4 during the period of this study (1982) varied as follows:

	L	C	R	M
Dry weather	1.6	1.0	1.4	1.0
Wet weather	2.0	1.4	1.2	1.1

This suggests that during combined sewer overflows the loss of DO in the river between transect 3 and transect 4 varied on the average from 0.2 to 0.4 mg/l, with the greatest loss occurring on the East Peoria side of the river and within the river channel. The mechanisms involved in this loss will be better defined in the BOD-DO modelling effort to be reported upon later. In the meantime it is important to emphasize that although some loss of DO occurred between transects 3 and 4 during combined sewer overflows, the violations of DO standards were minimal at this location. About 815 measurements were made for DO concentrations during three storm events. During one 30-minute run. across transect 4, DO concentrations of 3.1 mg/l were detected on the East Peoria side of the river at mid-depth and near bottom. For the same storm event, on another 30-minute pass across transect 4, DO concentrations of 4.9 mg/l were detected at near bottom in the channel and at the surface near shore on the Peoria side. In essence four measurements, all confined to transect 4, reflected DO concentrations below 5 mg/l. The violations were transitory — of not more than 30 minutes duration — and were detected early in a 3-hour sampling schedule involving 78 measurements for DO.

Table 7. Dissolved Oxygen Concentrations Observed During Variable Weather Conditions Encountered During Sediment Sampling During July 1 and 2

Date	Sky Condition	MP	DO (mg/l)
July 1	Sunny	165.72R	7.8
		165.30R	6.8
		164.40R	7.0
		163.82R	12.6
		163.62R	7.4
		163.61R	8.8
		162.94R	7.85
		162.90R	7.5
		162.77R	7.7
		162.71R	7.2
		162.68R	7.5
July 2	Cloudy	162.61R	5.8
		162.50R	5.8
		162.43R	5.6
		162.37R	5.9
		162.28R	5.75
		162.81R	5.9
		162.13R	5.8
	Partly cloudy	162.05R	6.0
		161.51R	6.2
		160.97R	6.2
		160.55R	5.8
		160.12R	5.8
		158.57R	6.2
	Mostly sun	158.57L	7.4
		166.12L	8.0
		160.55L	8.2
		160.97L	8.2
		161.51L	11.5

Table 8. Comparison of 3-foot Center Channel CSO DOs with Historical Data

	DO (mg/l) at 3-foot Channel Station					
	Minimum Value			Average Value		
Transect	1982 Dry	1982 Wet	1979 Dry	1982 Dry	1982 Wet	1979 Dry
1	6.85	6.00	5.30	7.77	7.32	6.31
2	6.65	6.60	5.40	7.79	7.83	6.51
3	7.40	6.40	5.30	7.50	7.68	6.44
4	6.50	5.20	5.30	6.80	6.36	6.32

pH. Numerically, pH represents the negative logarithm of the hydrogen-ion concentration in moles per liter. For practical purposes it reflects the acid or alkaline nature of water. A pH of 7 is neutral, that above 7 is alkaline, and that below 7 is acid. Section 302.204 of the PCB Rules and Regulations states that pH values for general use waters shall fall within the range of 6.5 and 9.0 except for variations due to natural causes.

The pH of a stream can vary widely because of natural biological activity or because of physical factors usually introduced or caused by humans. Plant growth in a stream or lake can cause wide fluctuations in pH over relatively short periods of time. Algae, through photosynthesis, can assimilate carbon via free carbon dioxide and bicarbonates during daylight hours, thereby increasing the pH. Photosynthetic activity may cause the pH to rise above 9 in highly productive waters during the day. On the other hand, the pH may decrease at night due to algal respiration. Industrial waste discharges and acid mine drainage can physically change the neutral pH of surface water. Almost all Illinois streams free of induced physical and chemical influences have pH values ranging between 6.5 and 9.0.

The range of pH values observed during the CSO study are summarized in table 9. Generally a narrow range of 7.5 to 8.7 was observed. With the exception of a pH of 6.35 detected at transect 3 on August 24, all the values met the standard. The one exception occurred in a surface sample collected at the right bank vertical. Notes recorded at that time indicate that the surface of the water was overlain with a considerable amount of extraneous debris such as grass trimmings and dead flies. This sample evidently represents an unusual slug of material that had only a localized and transient effect on water quality. As shown in table 9, pH values were generally in excess of 8.0 during dry weather as well as wet weather conditions, but they were never above 8.7. Algal activity was probably responsible for the higher values. Combined sewer overflows do not appear to have a significant effect on pH.

Total Ammonia-Nitrogen (NH_3-N). Total ammonia-nitrogen includes the ammonia form (NH_3) and the ammonium ion, the ionized state (NH_4^+). The proportion of each found in water is dependent upon a combination of temperature and pH conditions. For generalized temperature and pH conditions observed in the river during CSO sampling, approximately 95 percent of the total ammonia was in the ammonium form (NH_4^+). Section 302.212 of the PCB Rules and Regulations outlines a complex formulation for determining the allowable total ammonia-nitrogen concentration for variable temperatures and pH values. For the CSO sampling temperature range of 20 to 25°C and a pH of 8.0 to 9.0, the maximum allowable total ammonia concentration is 1.5 mg/l. The higher both the temperature and the pH, the lower the allowable total ammonia concentration. This is due to the fact that increases in both cause increases in the percent composition of ammonia (NH_3), the more toxic of the two forms. The PCB Rules and Regulations specify that for total ammonia-nitrogen ranging between 1.5 and 15.0 mg/l, un-ionized ammonia (NH_4^+) shall not exceed 0.04 mg/l, but for total ammonia less than 1.5 mg/l, 100

Table 9. pH by Date and Location
(L = Left Bank; C = Center; R = Right Bank;
M = Mixing Zone Looking Downstream)

Date	Transect Number	Range of pH L	C	R	M
			Dry Weather		
6/25	1	8.2-8.3	8.2-8.3	8.4-8.5	——
	2	8.1-8.2	8.0-8.1	8.0-8.1	8.1-8.1
	3	8.1-8.2	8.0-8.1	8.1-8.2	8.1-8.2
	4	8.1-8.2	8.1-8.2	8.1-8.2	8.2-8.2
9/14	1	8.4-8.7	8.5-8.6	8.6-8.7	——
	2	8.6-8.7	8.5-8.6	8.4-8.6	8.4-8.4
	3	8.2-8.3	8.3-8.4	8.4-8.4	8.3-8.4
	4	8.3-8.4	8.3-8.4	8.3-8.4	8.3-8.4
			Wet Weather		
6/28	1	8.0-8.1	8.0-8.1	8.2-8.2	——
	2	8.4-8.6	8.0-8.2	8.0-8.2	8.0-8.1
	3	8.1-8.2	8.1-8.2	7.8-8.0	7.9-8.0
	4	8.0-8.3	8.1-8.2	8.1-8.2	8.2-8.3
8/24	1	8.2-8.5	8.3-8.4	8.3-8.4	——
	2	7.7-8.5	8.2-8.5	8.3-8.4	8.3-8.4
	3	7.9-8.2	8.2-8.4	6.4-8.2	7.7-8.2
	4	8.2-8.5	8.2-8.5	8,2-8.4	8.3-8.4
9/17	1	8.2-8.4	8.2-8.3	8.3-8.5	——
	2	8.4-8.6	8.2-8.5	8.3-8.4	7.9-8.4
	3	8.0-8.3	8.2-8.4	7.5-8.4	7.7-8.4
	4	8.2-8.4	8.2-8.5	8.1-8.4	8.2-8.4

percent of this value may be NH_3. The ammonia tests performed during this study were for total ammonia concentrations. The percentage composition of (NH_3) vs. (NH_4+) was not directly determined.

Ammonia sources are many and varied. Quasi-natural sources can account for significant inputs into streams. These include urban and rural runoff, precipitation itself, and dust fallout. The primary sources, however, are related to human activities. They include farmsteads, sanitary landfills and dumps, industrial waste discharges, and treated and untreated domestic waste flows. In any event, ammonia is indicative of recent organic pollution.

Excessive ammonia concentrations can have profound effects on stream ecology. Relatively high levels of ammonia (NH_3) are toxic to aquatic organisms.. Ammonia is also readily oxidized by certain bacteria. This bacterial activity may depress the dissolved oxygen concentrations of a stream below acceptable limits. Experiments conducted by SWS indicate that ammonia (NH_3) concentrations as low as 0.4 mg/l can kill small bluegills under certain temperature and pH conditions. Its effect on the DO resources of the river will be evaluated as part of the DO-BOD modelling effort.

The in-stream concentrations of total ammonia-nitrogen during the study are summarized in table 10. In all cases, during both wet and dry weather conditions total ammonia concentrations are less than the stream standard of 1.5 mg/l. However, some localized increases, when compared with dry weather conditions, occur in the immediate area of outfalls during periods of overflow. This occurred on August 24 and September 17 in the mixing zone and at the right bank on transects 2 and 3. On August 24 at transect 3, maximum values of 0.89 and 0.82 mg/l were detected for the mixing zone and right bank locations, respectively. On the same date and at the same transect at the center and left bank locations, the maximum values observed were only 0,41 and 0.24 mg/l, respectively. Table 11 shows a comparison between the concentrations of total ammonia observed during the study and those obtained for 25 sampling runs made during the summer of 1979. The average concentrations at the 3-foot centerline depth during both periods are comparable although the 1979 maximum values were significantly greater than those observed during wet and dry weather conditions during 1982.

The average values for wet weather conditions were slightly higher than for dry weather conditions during this study. This suggests that concentrations of ammonia-nitrogen are elevated in the river during CSOs. Nevertheless the resultant in-stream values are well within the stream standards.

Cadmium. Cadmium is one of four heavy trace metals for which analyses were performed on the water and sediments of the river. The others are copper, lead, and zinc. All analyses represent the total concentrations of the metals.

Heavy metals in the environment can cause ecological and public health problems. However, the degree of significance of these effects has never been fully established. Generally, most trace metals are needed to mediate or promote many biochemical reactions. Some of the metal ions, at very low concentrations, are essential micronutrients for enzymatic transformations, but high concentrations of the same elements may inhibit or even be toxic to biological reactions. Cadmium has no known life-promoting biochemical function and has been proven to have cumulative toxic effects on plant and animal life when organism exposure is, either acute or chronic. Section 302.208 of the PCB Rules and Regulations limits cadmium concentrations in water to 0.05 mg/l.

In some areas of the country, natural weathering of rocks and the earth strata may introduce cadmium into the aquatic environment, but trace water contamination is due primarily to human activities. Cadmium, albeit in small

Table 10. Total Ammonia by Date and Location
(L = Left Bank; C = Center; R = Right Bank;
M = Mixing Zone Looking Downstream)

Date	Transect Number	Average L	Average C	Average R	Average M	Maximum L	Maximum C	Maximum R	Maximum M
					Dry Weather				
6/25	1	0.12	0.16	0.17	—	0.23	0.23	0.21	——
	2	0.13	0.16	0.18	0.11	0.20	0.34	0.23	0.13
	3	0.08	0.11	0.10	0.14	0.11	0.18	0.14	0.15
	4	0.13	0.11	0.10	0.12	0.21	0.16	0.14	0.12
9/14	1	0.14	0.19	0.14	—	0.15	0.22	0.18	——
	2	0.14	0.19	0.19	0.19	0.21	0.23	0.26	0.23
	3	0.33	0.19	0.21	0.22	0.38	0.30	0.26	0.26
	4	0.23	0.21	0.22	0.19	0.28	0.24	0.26	0.20
					Wet Weather				
6/28	1	0.13	0.13	0.16	—	0.26	0.21	0.29	——
	2	0.19	0.15	0.13	0.12	0.36	0.27	0.23	0.24
	3	0.18	0.16	0.19	0.14	0.38	0.40	0.38	0.23
	4	0.15	0.17	0.13	0.13	0.34	0.36	0.24	0.25
8/24	1	0.16	0.17	0.16	—	0.20	0.37	0.25	——
	2	0.18	0.18	0.17	0.13	0.31	0.27	0.23	0.18
	3	0.21	0.31	0.31	0.44	0.24	0.41	0.82	0.89
	4	0.19	0.21	0.22	0.21	0.41	0.31	0.33	0.24
9/17	1	0.21	0.19	0.20	—	0.34	0.32	0.30	——
	2	0.24	0.26	0.26	0.22	0.36	0.35	0.39	0.27
	3	0.26	0.24	0.37	0.39	0.35	0.33	0.93	0.67
	4	0.23	0.24	0.27	0.27	0.31	0.31	0.43	0.33

Table 11. Comparison of 3-Foot Center Channel CSO
Total Ammonia-Nitrogen Values with Historical Data

Transect	Maximum Value 1982 Dry	Maximum Value 1982 Wet	Maximum Value 1979 Dry	Average Value 1982 Dry	Average Value 1982 Wet	Average Value 1979 Dry
1	0.19	0.25	0.48	0.18	0.17	0.22
2	0,23	0.30	0.43	0.19	0,19	0.21
3	0.22	0.33	0.42	0.15	0.19	0.19
4	0.20	0.31	0.32	0.17	0.20	0.21

(Table 11 values: Total Ammonia-N (mg/l) at 3-foot Channel Station) quantities, is introduced into the general environment through particulate emissions from coal-fired power plants, vehicle emissions from oil consumption, and vehicle tire wear. Some industrial operations may result in direct discharges into sewer systems.

The results of the cadmium analyses are presented in table 12. All locations have averages of 0.01 mg/l or less. Only one analysis, a questionable one, exceeded the stream standard. That sample was from the channel on transect 1 upstream of all CSOs. Cadmium concentrations are not a significant contaminant in Illinois River water either above or below the combined sewer overflows.

Copper. Copper is a heavy metal which in trace amounts is needed to sustain certain plant and animal life processes. Human public health problems associated with the metal are very rare; however, at relatively moderate concentrations it can create ecological problems in an aquatic environment. The PCB standard (Section 302.208) for total copper in water has been set at 0.02 mg/l.

The toxicity concentration of dissolved copper in water is governed by several factors such as alkalinity, pH, organic substances, and complexing agents. In the form of copper sulfate, the metal is widely used to control algal blooms in lakes. Since many factors influence copper toxicity, specific algal toxic concentrations cannot be specified. Nevertheless, controlled studies have shown that, for natural waters, 0.01 mg/l of dissolved copper can inhibit the growth of some sensitive algal species and 0.04 mg/l can cause death. Studies conducted by SWS have shown that channel catfish are relatively sensitive to dissolved copper. A concentration of 1.2 mg/l was found to be lethal to these fish in highly alkaline waters.

In areas rich in copper ore, natural background levels of copper can be quite high in the aquatic environment. Generally, though, human activities account for the wide distribution of copper in surface waters. Activities related to heavy metal smelting and processing, heavy metal product manufacturing, coal-fired power generation, and metal plating subject the environment to copper contamination. Traffic has been reported to be a significant source of copper (probably from brake wear) in urban drainage. The appearance of copper in domestic sewage has been attributed mainly to copper plumbing.

The results of the copper analyses are presented in table 13. The water quality standard of 0.02 mg/l of total copper is violated persistently irrespective of dry or wet weather conditions, transects, or location on the transect. It was not uncommon to detect maximum concentrations of .04 mg/l during dry weather conditions. The highest value recorded during dry weather (0.13 mg/l) was on the right side of transect 1 near a heavy industrial operation upstream of all CSOs. Other significantly high values were found during wet weather conditions. On June 28 on the right at transect 4 a concentration of 0.21 mg/l was detected, and on August 24 in the mixing zone at transect 3 a concentration of 0.11 mg/l was observed.

Table 12. Cadmium By Date and Location
(L = Left Bank; C = Center; R = Right Bank;
M = Mixing Zone Looking Downstream)

		Cadmium Concentration (mg/l)							
	Transect	Average				Maximum			
Date	Number	L	C	R	M	L	C	R	M
						Dry Weather			
6/25	1	0.01	0.01	0.01	—	0.01	0.02	0.01	——
	2	0.01	0.01	0.01	0.00	0.01	0.01	0.03	0.00
	3	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01
	4	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
9/14	1	0.01	0.01	0.01	--	0.01	0.01	0.01	——
	2	0.01	0.01	0.01	0.01	0.03	0.02	0.01	0.01
	3	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01
	4	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
						Wet Weather			
6/28	1	0.01	0.01	0.01	—	0.01	0.06	0.01	——
	2	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	3	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	4	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03
8/24	1	0.01	0.01	0.01	—	0.01	0.01	0.01	——
	2	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	3	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	4	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
9/17	1	0.01	0.01	0.01	—	0.01	0.01	0.01	——
	2	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	3	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01
	4	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Table 13. Copper by Date and Location
(L = Left Bank; C = Center; R = Right Bank;
M = Mixing Zone Looking Downstream)

Date	Transect Number	Copper Concentration (mg/l) Average L	C	R	M	Maximum L	C	R	M
					Dry Weather				
6/25	1	0.02	0.01	0.04	—	0.03	0.02	0.13	——
	2	0.02	0.02	0.03	0.02	0.02	0.02	0.04	0.02
	3	0.02	0.02	0.03	0.01	0.04	0.04	0.04	0.01
	4	0.02	0.02	0.02	0.02	0.04	0.03	0.04	0.02
9/14	1	0.02	0.02	0.02	—	0.02	0.03	0.02	——
	2	0.02	0.02	0.03	0.02	0.04	0.03	0.04	0.02
	3	0.02	0.02	0.02	0.01	0.02	0.03	0.02	0.01
	4	0.02	0.02	0.02	0.02	0.03	0.04	0.02	0.02
					Wet Weather				
6/28	1	0.02	0.02	0.02	—	0.03	0.04	0.04	——
	2	0.02	0.03	0.02	0.02	0.05	0.09	0.04	0.03
	3	0.04	0.03	0.03	0.03	0.07	0.04	0.06	0.04
	4	0.03	0.03	0.04	0.02	0.04	0.04	0.21	0.04
8/24	1	0.02	0.02	0.02	—	0.04	0.04	0.03	——
	2	0.02	0.02	0.02	0.03	0.04	0.04	0.04	0.03
	3	0.03	0.03	0.03	0.05	0.03	0.06	0.05	0.11
	4	0.02	0.02	0.02	0.03	0.03	0.07	0.03	0.03
9/17	1	0.02	0.02	0.02	—	0.04	0.03	0.03	——
	2	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
	3	0.02	0.02	0.02	0.03	0.04	0.04	0.04	0.04
	4	0.02	0.02	0.02	0.02	0.04	0.04	0.03	0.03

Despite these transitory excursions of relatively high concentrations of copper, a review of table 13 for wet weather conditions indicates that on the average the impact of CSOs on the stream in terms of copper concentrations is imperceptible.

Lead. Lead, like cadmium, is an element that is non-essential to human biochemical processes. Evidence shows that lead can accumulate to levels poisonous to metabolic activities. Aquatic vegetation, including algae and macrophytes, is suceptible to lead uptake from water. Macrophytes tend to accumulate it in the leaves. Algae growth can be reduced or terminated depending upon other water conditions such as pH and nutrient availability. Studies have shown that in relatively soft water dissolved lead concentrations in the range of 0.075 to 0.136 are toxic to channel catfish. The PCB total lead standard in Section 302.208 of the Rules and Regulations is 0.10 mg/l.

Sources of lead in the aquatic environment are many and varied. Most notable are those related to human activities, including combustion of leaded gasoline, mine drainage, plating of wastes, battery manufacturing, coal burning, heavy metal manufacturing, and solid waste incineration. Lead has been found to be the main heavy metal detected in many urban storm drainage studies.

The results of the lead analyses are presented in table 14. Except for one location and date (the right bank station at transect 3 during the June 25 dry weather run), the average values were well below the standard of 0.10 mg/l. During wet weather, observed values in excess of the stream standards occurred at three locations on transect 2 on August 24, and on a left bank location at transect 4 on September 17. Only 4 of 654 samples collected downstream of CSOs during wet weather conditions exceeded the stream standard. It is quite apparent that the CSOs are not a major influence on river lead concentrations.

Zinc. Zinc is an element essential for good human health and is often considered the most important of all the micronutrients. its acute and chronic toxicity to fish and aquatic wildlife is less pronounced than that for most other heavy metals as exemplified by the relatively high standard of 1.0 mg/l set forth in Section 302.208 of the PCB Rules and -Regulations. Acute toxicity studies conducted by SWS indicate that 8.0 mg/l of soluble zinc is lethal to largemouth bass.

Input sources to the environment are principally those associated with mining and processing, metal plating industries, and solid waste incineration. Traffic (tire wear) and household plumbing and roof guttering are major sources in urban drainage.

The results of zinc analyses are presented in table 15. All average and maximum values fall well below the recommended standard, and no clear implication exists that the combined sewer system influences river concentrations.

Table 14. Lead By Date and Location
(L = Left Bank; C = Center, R = Right Bank;
M = Mixing Zone Looking Downstream)

		Lead Concentration (mg/l)							
	Transect	Average				Maximum			
Date	Number	L	C	R	M	L	C	R	M
					Dry Weather				
6/25	1	0.02	0.02	0.02	—	0.03	0.04	0.04	——
	2	0.02	0.02	0.02	0.03	0.04	0.02	0.03	0.03
	3	0.02	0.02	0.15	0.01	0.03	0.04	0.55	0.01
	4	0.02	0.02	0.02	0.04	0.04	0.04	0.04	0.04
9/14	1	0.02	0.02	0.02	—	0.03	0.03	0.02	——
	2	0.04	0.06	0.03	0.02	0.08	0.15	0.06	0.02
	3	0.02	0.02	0.02	0-04	0.02	0.02	0.03	0.05
	4	0.02	0.02	0.02	0.03	0.02	0.03	0.02	0.04
					Wet Weather				
6/28	1	0.02	0.02	0.03	—	0.04	0.03	0.06	——
	2	0.02	0.02	0.03	0.04	0.06	0.07	0.05	0.05
	3	0.03	0.02	0.03	0.04	0.05	0.05	0.06	0.05
	4	0.02	0.02	0.02	0.01	0.04	0.03	0.05	0.02
8/24	1	0.02	0.02	0.02	--	0.10	0.03	0.03	——
	2	0.03	0.05	0.06	0.02	0.27	0.18	0.52	0.03
	3	0.03	0.02	0.03	0.06	0.06	0.16	0.06	0.09
	4	0.02	0.02	0.02	0.01	0.04	0.04	0.04	0.01
9/17	1	0.02	0.02	0.02	—	0.03	0.03	0.03	——
	2	0.02	0.02	0.03	0.02	0.05	0.08	0.09	0.03
	3	0.02	0.02	0.03	0.01	0.07	0.05	0.08	0.02
	4	0.03	0.02	0.02	0.02	0.30	0.04	0.05	0.03

Table 15. Zinc By Date and Location
(L = Left Bank; C = Center; R = Right Bank;
M = Mixing Zone Looking Downstream)

		Zinc Concentration (mg/l)							
	Transect	Average				Maximum			
Date	Number	L	C	R	M	L	C	R	M
					Dry Weather				
6/25	1	0.04	0.04	0.04	—	0.05	0.05	0.04	——
	2	0.04	0.04	0.02	0.04	0.08	0.05	0.03	0.04
	3	0.04	0.04	0.07	0.06	0.04	0.05	0.15	0.08
	4	0.04	0.04	0.04	0.04	0.15	0.11	0.05	0.04
9/14	1	0.02	0.02	0.03	--	0.04	0.03	0.04	——
	2	0.02	0.03	0.02	0.02	0.05	0.08	0.04	0.03
	3	0.03	0.03	0.03	0.04	0.04	0.06	0.05	0.05
	4	0.02	0.02	0.02	0.03	0.05	0.04	0.02	0.04
					Wet Weather				
6/28	1	0.04	0.04	0.18	—	0.16	0.07	0.72	——
	2	0.05	0.07	0.06	0.06	0.18	0.38	0.18	0.08
	3	0.07	0.06	0.03	0.08	0.13	0.20	0.06	0.12
	4	0.04	0.04	0.04	0.03	0.06	0.07	0.06	0.04
8/24	1	0.03	0.03	0.04	—	0.08	0.12	0.06	——
	2	0.03	0.04	0.03	0.03	0.09	0.08	0.09	0.04
	3	0.03	0.03	0.05	0.10	0.06	0.06	0.07	0.15
	4	0.03	0.03	0.03	0.03	0.08	0.06	0.05	0.04
9/17	1	0.02	0.02	0.02	—	0.05	0.06	0.04	——
	2	0.02	0.02	0.03	0.03	0.03	0.04	0.14	0.05
	3	0.03	0.02	0.04	0.03	0.06	0.05	0.14	0.04
	4	0.02	0.02	0.02	0.03	0.04	0.04	0.04	0.06

Temperature. The physical, chemical, and biological characteristics of surface waters are temperature-dependent. Many ecological problems arise in an aquatic habitat when temperature extremes occur or fluctuate abnormally over short time periods. The status of a water body can be impaired or hindered by temperature changes to the extent that recreational uses become curtailed and aquatic fauna and flora become stressed. Sudden water temperature changes of only 2 or 3 degrees Fahrenheit can be fatal to sensitive fish such as shad. Also, the toxicity of many elements and compounds in water is temperature-dependent. Section 302.211 of the PCB Rules and Regulations specifies standards relative to maintaining stable water temperatures and minimizing heat input to surface waters. These standards are basically oriented toward regulating cooling water discharges. Those sections applicable to combined sewer discharges are: Paragraph b) There shall be no abnormal temperature changes that may adversely affect aquatic life unless caused by natural conditions; Paragraph d) The maximum temperature rise above natural temperatures shall not exceed 2.8°C (5°F); and Paragraph e) The June through September water temperatures shall never exceed 33.7°C (93°F).

The temperature measurements made directly in the river at the times of sampling are summarized in table 16. On the average the differences in temperature across the transects and between the transects did not differ significantly. However, there was a measurable difference between transect 1 and downstream transects with regard to observed maximum temperatures. Overall the violations of temperature standards did not occur during CSOs.

Suspended Solids. Suspended solids (SS) measurements reflect the amount of particulate matter a stream is carrying in suspension under certain velocity and flow conditions. This particulate suspended matter can originate directly from human by-products such as sewage and industrial wastes or indirectly from runoff associated with such human activities as surface mining operations, highway construction, and agricultural sites. Also, natural biological activities can produce suspended solids in surface water via plankton production. The latter, being of biological origin, is highly organic. The suspended solids of domestic sewage and some industrial wastes, contain a significant fraction of organic material also. Suspended sediments originating from land runoff are composed principally of soil particles. The same type of material is resuspended from the river bottom by barge traffic.

The Pollution Control Board has not set specific stream standards for suspended solids concentrations. Indirect reference is made to possible effects of suspended solids discharge in Section 302.203 (Unnatural Sludge) of the PCB Rules and Regulations stating that:

> "Waters of the State shall be free from unnatural sludge or bottom deposits, floating debris . . ."

Suspended solids washed into a stream during rain and high flows can settle to the bottom where they eventually affect wildlife and decrease recreational, commercial, and aesthetic values of a water course. Suspended

Table 16. Temperatures By Date and Location
(L = Left Bank; C = Center; R = Right Bank;
M = Mixing Zone Looking Downstream)

		Temperature (C)							
	Transect	Average				Maximum			
Date	Number	L	C	R	M	L	C	R	M
					Dry Weather				
6/25	1	22.9	22.8	22.8	—	23.1	23.0	23.0	—
	2	23.1	22.9	23.1	23.3	23.3	23.0	23.3	23.5
	4	23.9	23.8	23.7	23.6	23.8	24.0	23.9	23.7
9/14	1	23.9	23.8	24.1	—	24.2	24.0	24.2	—
	2	24.6	24.2	24.2	24.6	25.0	24.5	25.0	24.8
	3	24.9	24.9	24.8	24.9	25.0	25.0	24.8	25.0
	4	24.2	24.4	24.3	24.5	24.5	24.7	24.5	24.5
					Wet Weather				
6/28	1	23.8	23.8	23.6	—	23.9	23.9	23.8	—
	2	24.2	24.4	24.5	24.5	24.8	25.0	25.0	24.5
	3	25.0	25.0	25.0	25.0	25.0	25.0	25.2	25.1
	4	24.8	24.8	24.8	24.9	24.9	24.9	24.9	24.9
8/24	1	23.9	24.0	24.0	—	24.7	24.1	24.6	—
	2	23.6	23.8	23.9	24.0	24.5	25.6	24.8	24.5
	3	23.8	23.8	23.5	23.8	24.5	24.5	23.8	24.0
	4	22.8	23.2	23.1	22.8	23.5	23.5	24.0	24.0
9/17	1	20.3	20.3	20.7	—	2Q.4	20.5	20.8	—
	2	21.0	21.0	21.0	21.0	21.1	21.1	21.1	21.1
	3	21.6	21.6	21.7	21.6	21.8	21.8	21.8	21.8
	4	21.7	21.7	21.7	21.8	22.1	21.9	21.9	22.0

solids discharged from waste outfalls can build up sludge deposits in the areas immediately below the discharge points, causing severe localized environmental, ecological, and public health problems.

The results of the suspended solids analyses are shown in table 17. The overall wet weather data do not appear to be different from the dry weather data. In fact on June 25 during dry weather conditions the average suspended solids concentration was 104 mg/l. On June 28 during wet weather conditions the average concentration was 98 mg/l. The relatively high values for June 25 can probably be attributed to high algal production during the clear sunny day on which the run occurred.

The Water Survey routinely collects suspended sediment samples twice weekly above the Cedar Street overflow. Samples are collected from shore. The results for the last three years are summarized in table 18. Also included in table 18 are the results developed near shore during this study. In every case the yearly averages and maximums are higher than all of the averages or maximums for the near-shore locations sampled during CSOs. The minimum values for both yearly and CSO values fall within the same range.

Some localized heavy inputs of suspended solids did occur during wet weather conditions as evidenced by the relatively high values shown in table 17 for transect 2 on June 28 and August 24 and for transect 4 on August 24. The source of the high values at transect 2 is the Farm Creek diversion ditch which discharges above the Murray Baker bridge. On June 28 a large quantity of trash and very turbid water were observed coming from this area. Navigating through the area was difficult because logs, large tree branches, and other floating debris formed a barrier that extended almost across the width of the river. The high values observed at transect 4 probably were influenced by flow from Kickapoo Creek which discharges upstream of this transect. The instantaneous high value of 676 mg/l observed during this study, while relatively high compared to most of the other observations, is small compared to instantaneous suspended sediment concentrations observed by SWS on smaller Illinois streams. For example, SWS has observed an instantaneous concentration on the Spoon River of 4305 mg/l and a yearly geometric mean value of 446 mg/l. Comparatively, CSOs are not a major source of suspended solids to the sediment load of the river.

Turbidity. Turbidity can be defined as the measurement of the degree of opaqueness induced in water by suspended particulate matter. Turbidity measurements are made using an instrument called a nephelometer whereby light scattered by a water sample is compared to that scattered by a standard referent.

Turbidity may result from allochthonous materials (external sources) or autochthonous materials (internal sources) such as wind induced turbidity and algal blooms. Turbidity affects water quality in a number of ways, probably most significantly by quenching light penetration and by causing a rise of water temperature through heat absorption by suspended particulate matter.

Table 17. Suspended Solids by Date and Location
(L = Left Bank; C = Center; R = Right Bank;
M = Mixing Zone Looking Downstream)

Date	Transect Number	Suspended Solids Concentration (mg/l) Average L	C	R	M	Maximum L	C	R	M
					Dry Weather				
6/25	1	102	108	100	—	124	140	104	——
	2	76	96	105	92	80	124	146	98
	3	102	100	190	112	126	124	326	152
	4	80	77	86	132	106	90	110	103
9/14	1	28	35	34	--	36	44	38	——
	2	38	38	30	26	99	54	43	26
	3	52	41	45	30	67	51	46	31
	4	37	43	39	31	45	65	56	32
					Wet Weather				
6/28	1	64	68	75	~	88	84	80	——
	2	125	141	89	91	404	676	140	100
	3	154	99	139	67	305	130	380	97
	4	91	98	95	81	131	194	124	170
8/24	1	57	52	76	00	108	80	124	——
	2	105	59	54	48	304	252	92	60
	3	85	62	64	102	106	88	90	130
	4	72	53	55	47	614	114	88	58
9/17	1	38	46	38	—	52	100	46	——
	2	40	41	51	40	57	120	136	58
	3	43	38	42	34	128	65	70	44
	4	33	38	34	39	48	66	44	76

Table 18. Comparison of Mixing Zone CSO Suspended Sediment Samples
with SWS Samples Collected Twice a Week
above Cedar Street Outfall

Data	Suspended Solids (mg/l) Minimum	Average	Maximum
SWS Twice Weekly 1980	26	79	318
SWS Twice Weekly 1981	36	92	186
SWS Twice Weekly 1982	20	87	176
Transect 1 Right Surface Dry	30	67	94
Transect 2 Mixing Zone Dry	26	59	98
Transect 3 Mixing Zone Dry	28	71	152
Transect 4 Mixing Zone Dry	30	67	132
Transect 1 Right Surface Wet	26	56	96
Transect 2 Mixing Zone Wet	23	59	100
Transect 3 Mixing Zone Wet	24	68	130
Transect 4 Mixing Zone Wet	21	56	170

In general, there is a high, but not perfect, correlation between turbidity and suspended solids concentrations. No distinct relationship between turbidity and stream flow in Illinois has been shown by the large amount of data collected by SWS over a long time period. The PCB has not set a numerical limit for an acceptable level of turbidity. Section 302.203 of the Rules and Regulations states that waters of the state must be free of unnatural color or turbidity.

The turbidity results are presented in table 19. The variability and distribution follow very closely those described and discussed for suspended sediments. The influence of Farm and Kickapoo Creeks during wet weather is evident as are the effects of algal growth in the lake area during the dry weather run on June 25. The linear correlation coefficient between the average suspended solids concentrations and turbidity was computed as 0.98, indicating that approximately 96% of the variability in turbidity can be attributed to suspended sediments.

Table 20 includes a comparison between the wet and dry weather run data and twice weekly collections by SWS during 1980-1982. The historical data exhibit a wide range of values; the maximums for all three years were generally greater than any observed during the CSO study. This information indicates that CSOs do not contribute any significant amount of turbidity to the river.

Grease and Oil. Oil and grease determinations involve gross measurements of groups of substances having similar physical characteristics. The determinations are made quantitatively on the basis of common solubility in trichlorotrifluoroethane. Besides oil and grease the extraction can include sulfur compounds, some organic dyes, and chlorophyll.

Sources of grease and oil in waste and/or water collection systems are industrial and commercial operations, street runoff, automobile service stations, and railroad switching yards. Direct oil and grease contamination in a waterway may originate from pleasure and commercial boat operations. Outboard motors are notorious for spewing thin films of surface oil. Oil from barges and tows originates from bilge pumping and navigation accidents. Some heavy oils tend to be absorbed onto particulate matter and settle to the bottom under relatively quiet conditions. When disturbed these sediments can release oil into the water column.

The PCB has not set a numerical limit on the acceptable level of grease and oil in a stream. Section 302.203 of the Rules and Regulations merely states that water of the state must be free of visible oil.

Because grease and oii are generally lighter than water, only surface samples were collected for analysis at the stations on each transect. The results are summarized in table 21. Some differences appear to occur between dry and wet weather conditions. The wet weather data contain a number of values significantly higher than those observed during the dry conditons. However, these high values do not appear to be confined to any one section

Table 19. Turbidity by Date and Location
(L = Left Bank; C = Center; R = Right Bank;
M = Mixing Zone Looking Downstream)

Date	Transect Number	Turbidity Expressed in ntus- Average L	Average C	Average R	Average M	Maximum L	Maximum C	Maximum R	Maximum M
					Dry Weather				
6/25	1	100	103	101	—	119	144	107	—
	2	76	95	103	96	80	122	130	100
	3	98	96	170	116	118	111	288	150
	4	83	82	86	97	104	91	108	108
9/14	1	35	38	35	—	40	44	37	—
	2	36	38	34	28	72	48	41	28
	3	47	38	42	36	56	46	48	37
	4	39	43	36	34	42	55	40	34
					Wet Weather				
6/28	1	77	81	87	—	96	90	93	—
	2	125	124	86	85	404	489	122	91
	3	130	97	139	67	204	118	380	97
	4	80	91	98	82	112	119	104	111
8/24	1	66	60	80	—	98	80	112	—
	2	100	64	58	48	210	188	78	52
	3	71	64	60	73	98	82	74	99
	4	66	58	58	50	333	90	82	60
9/17	1	36	40	33	—	44	67	37	—
	2	40	39	43	35	48	80	93	44
	3	42	38	38	35	79	55	53	44
	4	36	38	35	36	53	55	42	50

Table 20. Comparison of Mixing Zone CSO Turbidity-
Samples with SWS Samples Collected Twice a Week
above the Cedar Street Outfall

Data	Turbidity (ntu's). Minimum	Average	Maximum
SWS Twice Weekly 1980	17	39	133
SWS Twice Weekly 1981	14	43	117
SWS Twice Weekly 1982	13	56	162
Transect 1 Right Surface Dry	35	67	99
Transect 2 Mixing Zone Dry	27	59	96
Transect 3 Mixing Zone Dry	34	65	116
Transect 4 Mixing Zone Dry	33	71	108
Transect 1 Right Surface Wet	27	59	94
Transect 2 Mixing Zone Wet	26	60	91
Transect 3 Mixing Zone Wet	30	58	99
Transect 4 Mixing Zone Wet	29	57	111

Table 21. Surface Grease and Oil by Date and Location
(L = Left Bank; C = Center; R = Right Bank;
M = Mixing Zone Looking Downstream)

		Grease and Oil Concentration (mg/l)							
	Transect	Average				Maximum			
Date	Location	L	C	R	M	L	C	R	M
					Dry Weather				
6/25	1	1.0	1.0	1.0	—	1.0	1.0	1.0	—
	2	1.0	1.0	1.0	1.0	1.0	1.0	l.0	1.0
	3	1.0	1.0	1.0	2.0	1.0	1.0	1 0	3 0
	4								
9/14	1	1.5	2.0	2.0	—	2.0	3.0	3.0	—
	2	1.6	2.2	1.9	1.5	2.0	2.3	2.0	2 0
	3	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0
	4	2.5	2.5	2.0	3.6	2.9	2.9	3.0	3.9
					Wet Weather				
6/28	1	1.2	1.3	1.7	—	2.1	2.1	2.0	—
	2	2.8	2.0	1.6	1.8	4.0	4.0	2.2	4.0
	3	3.0	3.8	10.5	2.0	5.2	10.6	24.0	3.0
	4	2.2	2.4	3.3	1.8	4.0	4.0	5.0	3.4
8/24	1	1.1	1.9	1.5	—	1.6	6.5	4.2	—
	2	1.3	1.7	1.5	1.5	3.0	3.0	3.0	2.3
	3	1.6	1.2	3.5	9.3	4.0	2.0	8.0	28.0
	4	1.8	1.9	1.5	1.0	3.9	3.0	4.0	1.2
9/17	1	8.4	1.6	1.4	—	45.6	3.4	2.5	—
	2	1.0	1.0	1.8	1.8	1.0	1.0	3.0	4.0
	3	1.6	1.4	2.7	1.0	2.7	3.5	9.0	1.0
	4	3.6	1.2	1.2	2.0	16.1	2.4	2.0	3.0

or point in the river. The highest value recorded (45.6 mg/l) was for the left bank station on transect 1, the most unlikely point for such a value to occur. Other high values were recorded in the CSO discharge areas and at the left bank station at transect 4. No clear evidence exists indicating the primary source of these localized increases in grease and oil during wet weather. The actual significance of these "spot highs" is difficult to determine since no historical information is available with which to make comparisons.

Fecal Coliform. Coliform bacteria have been used to measure the occurrence and intensity of fecal contamination of water for approximately 60 years. Initially total coliform (TC), a heterogeneous group of bacteria referred to as indicator organisms, was used to evaluate the public health aspects of water. The absence of TC was considered evidence of bacteriologically safe water since these bacteria are always present in the intestines of warm-blooded animals. However, several species of the total coliform group also originate from soil, which complicates water quality assessments. Presently, fecal coliform (FC), a subgroup of TC bacteria which is primarily of human origin, is being used to evaluate fecal pollution. Their preponderance is taken principally as evidence of human fecal origin.

Historically, the Pollution Control Board has set standards specifying fecal coliform limits in streams for general use. Section 302.209 of the December 1982 edition of the Rules and Regulations states that these standards have been repealed, but in fact this is not the case. The Pollution Control Board's efforts to repeal the standard are being considered by the appellate court, so the status of the standard remains unclear as part of the Rules and Regulations. The standard states:

> "Based on a minimum of five samples taken over not more than a 30-day period, fecal coliforms shall not exceed a geometric mean of 200 per 100 ml, nor shall more than 10% of the samples during any 30-day period, exceed 400 per 100 ml."

The fecal coliform densities observed in this study are summarized in table 22. Geometric means have been used. The effect of discharges from the combined sewer system on the bacterial content in the river is clearly evident. Definite temporal and spatial patterns exist. Fecal coliform counts for dry weather conditions are low (within reasonable limits of the standard) throughout the study area. The densities are very low for the lake station (transect 1) but are somewhat variable downstream. Discharges from the two East Peoria sewage treatment plants, the Caterpillar wastewater treatment plant, and the Peoria Sanitary District plant account for this variability. During the wet weather conditions the densities at transect 1 remain very low but those at transects 2 and 3 exhibit significant increases. Particularly significant is the fact that the highest counts occurred nearshore, i.e., at the mixing zone and right bank locations along the Peoria side of the river. During the June 28 and August 24 events when the highest rain intensities occurred, much higher densities of fecal coliform were recorded than for the September 17 event, which was a moderate rainfall event (see table 5).

Table 22. Fecal Coliform By Date and Location
(L = Left Bank; C = Center; R = Right Bank;
M = Mixing Zone Looking Downstream)

		Fecal Coliform Counts per 100 ml							
	Transect	Geometric Average				Maximum			
Date	Number	L	C	R	M	L	C	R	M
						Dry Weather			
6/25	1	4	14	3	—	20	20	10	——
	2	39	5	35	49	50	30	40	60
	3	49	148	209	194	60	200	230	250
	4	69	105	109	39	80	110	170	50
9/14	1	4	22	5	—	20	50	30	——
	2	73	22	134	160	270	50	200	170
	3	110	184	141	205	150	340	200	210
	4	89	65	69	205	100	70	80	700
						Wet Weather			
6/28	1	20	38	13	—	100	300	20	——
	2	304	137	6,129	31,618	1,700	2,100	11,000	102,000
	3	2,254	1,053	65,263	70,705	8,200	6,900	167,000	109,000
	4	566	1,163	855	658	15,200	15,200	4,400	1,690
8/24	1	5 7	- 3 5	3	—	650	4,900	60	——
	2	367	1,864	12,509	11,820	3,600	22,400	35,000	20 000
	3	2,232	8,764	45,150	82,367	5,300	32,500	87,000	100 000
	4	271	371	1,304	3,673	970	1,960	6,600	21,000
9/17	1	9	22	5	—	30	70	20	——
	2	134	28	143	337	1,000	560	1,860	3,500
	3	327	139	2,682	3,381	1,320	1,000	160,000	240,000
	4	43	125	76	15	150	6,800	2,700	50

Some historical data exist relative to bacterial sampling in the river at Peoria. SWS conducted a 5-year study between 1971 and 1976 on the weekly variability of fecal coliform densities in the river just above the Cedar Street outfall. The sampling location would be comparable to a mixing zone location. Table 23 presents a comparison of the densities observed at mixing zone locations during this study and those obtained just upstream of the Cedar Street outfall during the 5-year study. Also included are observations for 11 centerline samples collected during the summer of 1979 near transect 3. These data indicate that the FC counts in the area of the outfalls (transects 2 and 3) during and immediately after a significant rain in the downtown Peoria area are extremely high compared to long-term averages. During dry weather conditions the counts are much less than for wet weather conditions and significantly less than the long-term data. The 1971-1976 data contain a number of samples collected during relatively wet weather periods. These are responsible for the higher counts relative to the dry weather results. A conclusion that was reached in the SWS report on the results of the 5-year study was that about 50 percent of the bacterial count increases are associated with precipitation. This conclusion was reached by comparing fecal coliform densities obtained after a minimum 24-hour, 0.3-inch rain with those obtained three days prior to such an event.

Two analytical laboratories (Randolph and Associates, and Daily and Associates) shared the responsibility for handling the bacterial samples and performing other analyses such as those for grease and oil and heavy metals. A quality control program was established. Replicate analyses were performed on 5 percent of the river samples collected for a given parameter. The results of the bacterial replicate analyses are presented in table 24; good overall agreement is shown with the exception of the cases marked with an asterisk. The replicates were chosen from transects 1 and 4 as suggested by SWS. Since each laboratory handled samples taken on alternate runs for all of the transects, a rough comparison can be made of the results from each laboratory. The comparisons are shown in table 25.

The tabulation shows that in most cases the results produced by one laboratory on a given run compare favorably with those produced by the other laboratory on either the preceding or succeeding run. Some differences in successive runs did occur. Nevertheless, on an overall basis the bacterial results show realistic patterns and orders of magnitude not unexpected.

Biochemical Oxygen Demand (BOD). The biochemical oxygen demand test is used to measure the biologically oxidizable material dissolved or suspended in water. The microbial respiration rates associated with the BOD are determined empirically by measuring the reduction in dissolved oxygen of a contained sample over a period of time. Essentially it is a test designed to ascertain the oxygen demand potential of water and wastewater. There is not a BOD stream standard in Illinois.

Microbial oxygen usage in water and wastewater results from two distinct biochemical processes: carbonaceous or first stage demand (BOD_c) and nitrogenous or second stage demand (BOD_n). The first stage BOD represents the degradation of carbonaceous (organic) material by a myriad of saprophytic

Table 23. Comparison of CSO
Fecal Coliform Counts With SWS Samples
Collected Twice Weekly Above Cedar Street Outfall
and 1979 Data at Center Transect 3

	Fecal Coliform (counts/100 ml)		
Data	Minimum	Geometric Avg.	Maximum
June 1971-1976 Cedar St.	130	460	1,600
July 1971-1976 Cedar St.	48	480	8,300
August 1971-1976 Cedar St.	48	290	2,500
September 1971-1976 Cedar St.	130	420	6,700
Transect 1 Right Surface Dry	0	4	30
Transect 2 Mixing Zone Dry	30	86	170
Transect 3 Mixing Zone Dry	150	199	250
Transect 4 Mixing Zone Dry	30	89	700
Transect 1 Right Surface Wet	0	6	60
Transect 2 Mixing Zone Wet	10	5,014	102,000
Transect 3 Mixing Zone Wet	70	27,003	240,000
Transect 4 Mixing Zone Wet	0	331	21,000
Transect 3 Center CSO Dry	100	165	340
Transect 3 Center CSO Wet	3	1,084	8,764
Transect 3 Center 1979	110	460	1,400

Table 24. Comparison of Interlaboratory Replicate Analysis Results For Fecal Coliform

Date	Transect Number	Replicate Sample FC Counts per 100 ml Randolph	Daily
6/25/83	4	130	170
		70	110
		50	60
		70	50
6/28/83	1	20	10
		<10	o
		80	0
	4	3,000	2,500
		900	2,000
		300	410
		4,400	7,300
8/24/83	1	10	0
		10	40
		60	0
		100	0
	4	2,300	2,200
		100	160
		30	240
		90	1,700*
9/14/83	1	30	30
		10	10
		60	0
		20	0
	4	370	80
		80	70
		30	80
		2,400	60*
9/17/83	1	10	0
		80	10
		130	0
		20	0
	4	160	10
		270	0*
		510	40*

* Probable inconsistencies

Table 25. Comparison of Interlaboratory Fecal Coliform Results

			FC Counts/100 ml at Water Surface							
	Transect	Run	L		C		R		M	
Date	Number	Number	R*	D*	R	D	R	D	R	D
6/28/82	2	1		1,700		800		11,000		11,000
		2	1,000		30		5,300			42,000
		3		100		2,100		11,000		120,000
		4	150		10		9,000			53,000
		5		110		100		1,800		20,000
		6	280		130		5,100			20,000
	3	1		100		550		81,000		39,000
		2	8,200		400		60,000			85,000
		3		3,700		1,000		119,000		37,000
		4	4,300		500		167,000			89,000
		5		1,500		1,800		8,000		105,000
		6	6,700		6,900		100,000			109,000
8/24/82	2	1		60		170		1,300	19,500	
		2	3,600		10,100		35,000		5,100	
		3		490		310		6,200	20,000	
		4	420		3,200		19,400		7,200	
		5		460		1,100		20,000	12,700	
		6	120		22,400		35,000		15,000	
	3	1		540		4,100		59,000		65,000
		2	1,600		32,500		21,000			72,000
		3		2,700		13,000		44,000		67,000
		4	5,300		3,400		38,000			96,000
		5		2,700		7,400		47,000		100,000
		6	3,700		10,400		87,000			97,000
9/17/82	2	1		40		0		20		2,100
		2	20		-		70			40
		3		130		40		60		10
		4	130		10		100			3,500
		5		1,000		560		550		500
		6	430		80		1,860			1,000
	3	1		30		3		0	1,700	
		2	1,320		1,000		80		70	
		3		930		140		160,000	2,200	
		4	-		540		45,000		240,000	
		5		210		60		4,300	580	
		6	480		520		1,880		41,000	

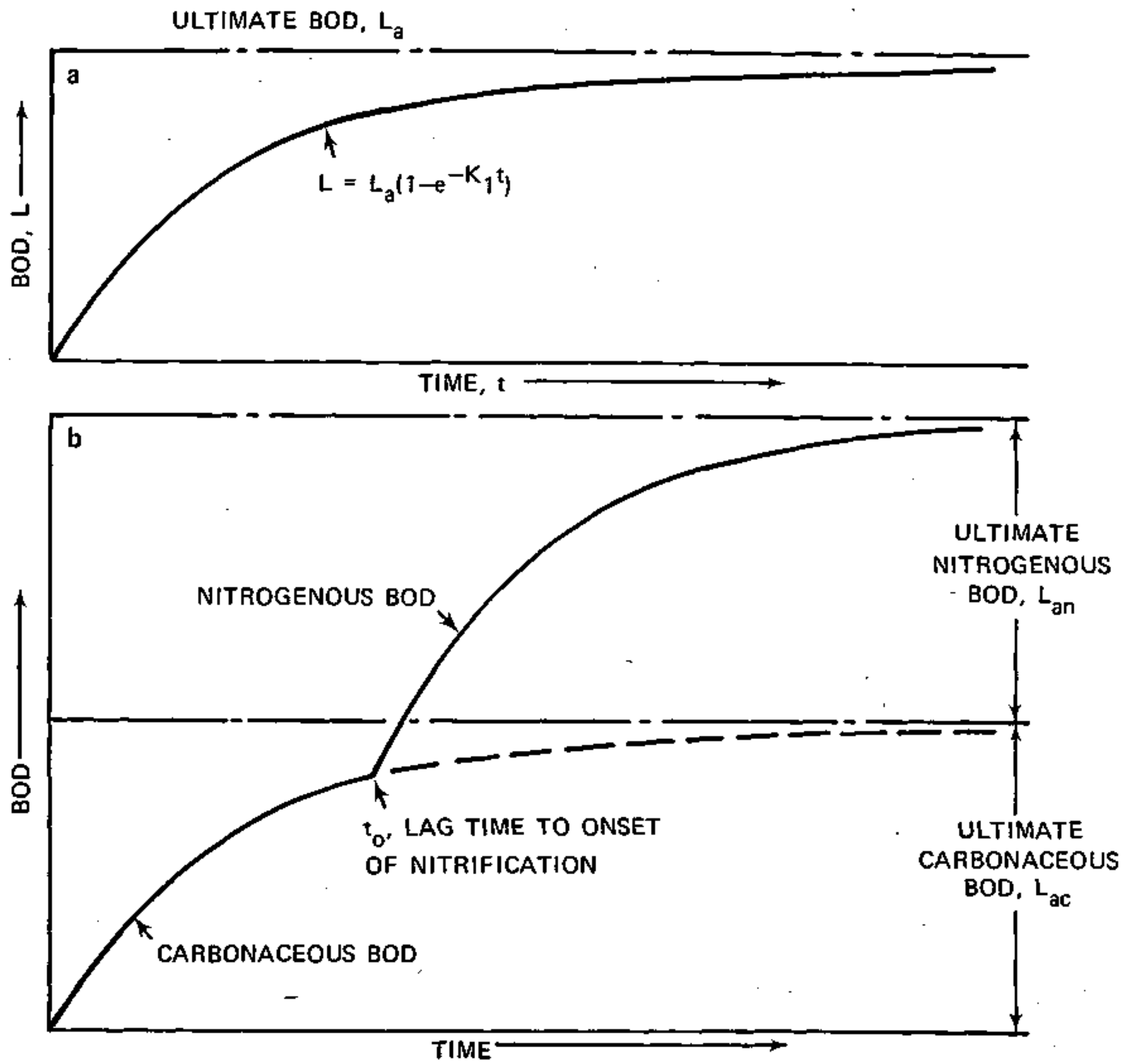
* R = Randolph & Assoc.; D = Daily & Assoc.

microorganisms. The second stage BOD represents the biochemical utilization of ammonia as a source of energy by a select group of autotrophic bacteria. Idealized curves demonstrating these two biological processes are shown in figure 3. These curves usually conform to first order kinetics which can be represented by the mathematical expression presented in figure 3a. By experimentally recording DO usage (L) versus time (t) and fitting data points to the equation, the rate (K_1) of oxygen usage and the ultimate (L_a) or maximum possible DO usage can be ascertained. In fresh wastewater, the nitrifying bacterial population needs time to build up to viable numbers and to acclimate to conditions, whereas the carbonaceous bacteria are much more hardy and ubiquitous. This accounts for the lag time (t_o) for the onset of the nitrogenous BOD curves as shown in figure 3b relative to the beginning of the carbonaceous curve. However at Peoria, because of the large input of wastes from upstream sites, a viable nitrifying bacterial population is established, and t_o usually is a small positive or negative number or is zero. Since the nitrifying bacteria are very sensitive to environmental conditions, the carbonaceous BOD can be isolated by chemically inhibiting the growth of the nitrifying bacteria. The nitrogenous BOD curve can then be indirectly determined by subtracting the carbonaceous values from uninhibited values (total BOD).

BOD samples were collected during the second and last runs at the mid-depth of locations R, C, and L at transects 1 and 3 and at location C on transect 4. Typical BOD progression curves (represented by the June 28 data) are presented in appendix A, and the overall results are summarized in table 26. The tabular values represent the ultimate BOD values (L_a) estimated by fitting sequential 21-day DO usage versus time data (see appendix A) to the equation shown in figure 3a. During the overflow events on June 28 and August 24, transect 3 exhibited slightly higher total BOD concentrations than did transect 1. On September 17, the differences in total BOD for all transects were minor. Both the Peoria and East Peoria sides of the river produced total BODs of about equal magnitude. This suggests that the higher BODs in the river on the Peoria side may not be due solely to CSOs. Overland flow and nonpoint urban surface drainage may be important contributors also.

Comparisons between average BODs observed in the channel during this study and the average BODs observed in 1979 on six dates during dry weather conditions are presented in table 27. The dry weather BODs show a steady decrease in the downstream direction, closely following first order kinetics described by figure 3a. Those observed for the CSOs that occurred on June 28 show significant increases downstream. A similar examination of the overflow events occurring on August 24 and September 17 does not reveal a predictable trend.

The average BOD reaction rates (K_1 in figure 3a) are summarized in table 28. Also listed in table 28 are the ratios of the average ultimate carbonaceous BOD (L_{ac}) and the average ultimate nitrogenous BOD (L_{an}). The carbonaceous BOD progressed at significantly higher rates than did the nitrogenous BOD. The rates of reaction and the relationships of carbonaceous versus nitrogenous BODs will be useful for the DO-BOD modeling effort to be



(1) GENERAL EQUATION OF CARBONACEOUS DEOXYGENATION

$$C_xH_yO_z + O_2 \xrightarrow[\text{Microorganisms}]{\text{Saprophytic}} CO_2 + H_2O$$

(2) GENERAL EQUATION OF NITROGENOUS DEOXYGENATION

$$2NH_3 + 3O_2 \xrightarrow[\textit{Nitrosomonas Sp}]{\text{Nitrite Formers}} 2\,NO_2^- + 2H^+ + 2H_2O$$

$$2NO_2^- + O_2 \xrightarrow[\textit{Nitrobacter Sp}]{\text{Nitrate Formers}} 2\,NO_3^-$$

Figure 3. a) Schematic of first order BOD curve
b) Schematic carbonaceous-nitrogenous BOD curve

Table 26. Ultimate BOD Concentrations (mg/l)
Power 1; t_o =0

BOD Type	Transect Number	Run Number	6/28/82 L	6/28/82 C	6/28/82 R	8/24/82 L	8/24/82 C	8/24/82 R	9/17/82 L	9/17/82 C	9/17/82 R
Total	1	2	9.64	11.94	11.88	10.57	10.64	10.83	11.69	12.65	14.81
		6	9.32	9.33	10.84	12.24	10.37	10.95	11.70	11.64	11.45
	3	2	19.65	12.01	18.44	15.96	13.36	13.27	11.82	11.66	11.37
		6	15.59	10.40	15.96	11.37	10.74	11.47	14.17	11.88	13.14
	4	2	—	16.28	—	—	8.85	—	—	11.97	—
		6	—	11.48	—	—	9.79	—	—	11.58	—
Carbonaceous	1	2	4.98	6.64	7.16	4.99	4.38	4.65	5.26	5.73	6.66
		6	4.76	5.09	6.53	5.55	4.35	4.40	5.21	5.44	5.52
	3	2	11.43	5.87	12.43	8.03	6.66	8.29	5.12	5.35	4.95
		6	4.56	9.73	11.43	4.79	4.39	8.20	6.03	5.24	6.05
	4	2	—	6.72	—	—	3.99	—	—	5.50	—
		6	—	5.79	—	—	4.77	—	—	4.75	—
Nitrogenous	1	2	5.85	6.58	6.32	6.43	6.61	6.85	6.46	6.92	8.16
		6	5.37	5.70	4.78	7.63	6.22	6.43	6.68	5.19	5.98
	3	2	8.91	7.04	7.57	8.85	6.63	5.42	6.49	6.19	6.57
		6	7.83	6.47	6.14	6.08	6.57	4.50	7.40	6.68	7.23
	4	2	—	10.35	—	--	4.68	--	—	6.21	—
		6	—	5.98	—	—	5.41	—	—	6.59	—

Table 27. CSO Centerline BOD Values Compared To 1979 Data

BOD Type	Transect Number	Average Ultimate BOD in Center Channel: CSO 6/28/82	CSO 8/24/82	CSO 9/17/82	Three CSO Dates	Six 1979 Samples
Total	1	10.64	10.51	12.15	11.10	10.00
	3	11.21	12.05	11.77	11.68	9.77
	4	13.88	9.32	11.79	11.66	8.37
Carbonaceous	1	5.87	4.36	5.59	5.27	5.45
	3	7.80	5.53	5.30	6,21	5.04
	4	6.26	4.38	5.13	5.26	4.55
Nitrogenous	1	6.14	6.42	6.06	6.21	4.78
	3	6.76	6.60	6.44	6,60	4.94
	4	8.17	5.05	6.40	6.54	3.99

Table 28. Summary of BOD Rates and Ratios

Date	Transect Number	Average K (1/day): Total	Carbonaceous	Nitrogenous	Average Ratio of L_{ac}/L_{an}
6/28	1	0.1113	0.1182	0.0780	1.02
	3	0.1265	0.1459	0.0920	1.17
	4	0.1202	0.1393	0.0973	0.81
8/24	1	0.1020	0.1604	0.0656	0.70
	3	0.1124	0.1566	0.0722	1.12
	4	0.1000	0.1633	0.0629	0.87
9/17	1	0.0963	0.1539	0.0707	0.86
	3	0.0938	0.1585	0.0652	0.81
	4	0.0859	0.1450	0.0629	0.81

undertaken later. It is clear at this time however that the BOD of the river water is influenced by urban drainage and that the higher concentrations of total BOD occur within near-shore stations on both sides of the river.

Visual Notations. Section 302.203 of the Rules and Regulations of the Pollution Control Board states, in part, that waters of the state shall be free from floating debris, visible oil, odor, unnatural plant or algal growth, unnatural color or turbidity or matter of other than natural origin in concentrations toxic or harmful to human, animal, plant, or aquatic life. Our original intention was to use photography to document any observations that could be construed to be in conflict with these regulations, but this proved impracticable for this study. Reliance was therefore placed on visual notations recorded after, storm events.

At the onset of CSOs above transect 2, especially during the storm events of June 28 and August 24, large quantities of floating debris were observed coming downstream on both sides of the river. The debris from the east side of the river presumably originated primarily at Farm Creek and consisted of logs and nondescript trash. The debris on the Peoria side consisted of "rafts" of cigarette butts, grass clippings, paper wrappers, styrofoam food containers, condoms, soda cans, and the like. Grass clippings extended to the channel at transect 2. Some oil skim was seen but its origin (east side vs. west side) was difficult to determine. During the September 17 event there was much less floating debris at transect 2.

At transect 3 the floating debris was less dense, but field notations indicated that grass clippings and dead flies might have influenced some of the water samples collected. The impact of the June 28 event persisted at transect 3 for at least four days as evidenced by floating containers including several hundred condoms at near shore locations. Oil was not evident on September 17 until the sun broke through late in the evening and a slight oil sheen appeared widespread in the study area.

Other than floating debris and visible oil there were no observations that might be considered in conflict with the Pollution Control Board rules and regulations.

From the description provided it is quite likely that some of the floating debris originates from the combined sewer system; however, some of it does not. The origin of oil is most difficult to identify as previously noted in the discussion on grease and oil concentrations in water samples collected from various locations.

River Sediment Sampling

River bottom sediments were collected at 28 locations on two occasions for the examination of particle size distribution, solids, volatile solids," grease and oil, and concentrations of certain metals. The locations are depicted in figures 1 and 2 and listed by milepoint in table 2. With regard to CSOs they were located as follows:

3 upstream of all CSOs on the Peoria side
19 in the vicinity of CSOs
1 downstream of all CSOs on the Peoria side
5 on the East Peoria side

Collections were made during July 1982 and March 1983.

In addition to the collection of bottom sediments for physical and chemical examination, sediments were also collected at 19 locations for laboratory SODs and benthos evaluation. At these stations *in-situ* SOD measurements were performed. The work for benthos collections and in-field SODs was accomplished during October 1982. The locations of the 19 stations are also included in table 2 and shown in figures 1 and 2.

An examination of stream bottom sediments in terms of their physical characteristics and metal content coupled with the types and number of aquatic organisms they sustain indicates the long-term ecological health of a stream. The quality of the overlying water may vary considerably and the characteristics of a water sample collected on one day frequently represent a transient condition. Bottom sediments on the other hand tend to be more stable and exhibit average conditions over a relatively long period of time.

The river sediment activities that were included in this study were designed to define the types and nature of sediments, detect the existence of sludge deposits if present, and determine the suitability of bottom sediments as substrate for benthos development, all in relation to the impact of CSOs.

Photographs of the sediments collected are included in appendix B.

Physical Characteristics. Descriptions of the bottom sediments collected on two occasions are included in table 29. These descriptions coupled with the photographs in appendix B indicate that bottom sediments in the vicinity of CSOs consist mainly of sand or sand and rock. The particle size distribution of the sediment, as summarized in tables 30 and 31, documents these observations.

As mentioned earlier there was an 8-month intervening period between the two collection periods. During the time between July 1982 and March 1983 near record flood flows occurred. Despite these conditions only minor changes were observed in the makeup of the bottom sediments at CSO locations. Sediment stations 4 and 6 (Caroline St. and Morgan St. CSOs) changed from predominantly silt and clay to sand or sand and rock; and sediment station 7 (Green St. CSO) changed from predominantly rock to silt and clay. Sediment station 5 (Spring St. CSO) remained predominantly silt and clay, while the composition of sediments in the vicinity of all the other CSOs remained essentially sand or a sand and rock mixture. It is probable that some of the observed changes may have been caused by an inability to sample the identical site over an 8-month interval, but even if this was the case the evidence strongly indicates that the concept of bottom sediment stability is well founded.

Table 29. Sediment Sample Descriptions

	Visual Description of Ponar Dredge Sediment Samples	
Station	Three to Four Days After Overflow (7/1, 7/2/82)	Two Weeks After Overflow (3/1/83)
1	Tan-gray silty sand	Gray sandy silt
2	Tan-gray silty sand with some fibrous detritus and pebbles	Tan-gray slightly sandy silt with some fibrous detritus
3	Pasty sandy tan-gray silt	Gelatinous tan-gray silt with some fine sand
4	Gelatinous, gritty tan gray silt	Gray silty sand with embedded pebbles and fibrous detritus
5	Pasty, gritty tan-gray silt, piece of cellophane	Pasty gray sandy silt with stringy detritus
6	Creamy, gray clayey silt	Tan-gray silty sand with some gravel and leafy detritus
7	Thin watery layer of silt over gravel and coarse sand	Tan-gray sandy silt with some gravel, and shell fragments
8	Clean rocks and gravel	Sandy silt with many rocks and shells
9	Slight silt layer over gravel and coarse sand	Sandy gravel with some silt and shells
10	Assorted sand and gravel	Gravelly sand with some silt
11	Slightly silty sand with some pebbles, shells and detritus	Watery sand, slightly silty with some pebbles and sticks
12	Assorted rocks and gravel	Dirty sand, some pebbles and shell fragments
13	Some large rocks, gravel and coarse sand	Clean sandy gravel, a few shells
14	A large rock, gravel, coarse sand and a few shells	Gravelly sand with shells
15	A brick, rocks and coarse sand	Clean gravelly sand
16	Rocks, a live mussel, and slightly silty sand	Sand and small gravel
17	Various size rocks with a few shells	Assorted gravel and shells with some sand
18	Assorted rocks with some sand	Small to large rocks and shells
19	Small rocks and gravel in clean gray coarse sand	Assorted rocks gravel, coarse sand, some shells
20	Assorted gravel and coarse sand with some silt	Fine black sand with some pebbles
21	Thin layer of silt over sandy gravel	Gray sand and fine gravel
22	Watery silty sand	Tan-gray silty sand
23	Thin sandy layer over compact gray silty sand	Tan-gray silty sand
24	Gelatinous tan-gray clayey silt	Pasty tan-gray clayey silt
25	Thin watery silt layer over clean sand with a few rocks	Clean medium sand
26	Watery silt layer over clean sand	Thin silt layer over clean sand with some shells
27	Thin watery silt layer over clean medium sand	Clean medium sand
28	Watery silt layer over sand with gravel and shells	Clean sand and small gravel

Table 30. Particle Size Distribution of Bottom Sediments from Illinois River During July 1982 (Percent by Weight)

Sediment Station	% Clay	% Silt	% Clay & Silt	% Sand	% Rock	% Detritus	% Shells
1	10.0	11.1	21.1	76.0	1.7	1.2	o.0
2	6.2	10.5	16.7	75.2	4.1	4.0	0.0
3	31.4	37.6	69.0	30.0	0.7	0.3	0.0
4	42.2	40.5	82.7	17.1	0.0	0.2	0.0
5	30.8	51.5	82.3	17.3	0.0	0.4	0.0
6	45.1	48.6	93.7	6.2	0.0	0.1	0.0
7	1.3	1.5	2.8	28.5	68.0	0.7	o.0
8	0.1	0.2	0.3	1.3	98.4	0.0	0.0
9	1.3	2.8	4.1	42.2	45.3	0.0	5.4
10	0.6	1.0	1.6	47.2	50.7	0.5	0.0
11	7.1	8.4	15.5	81.2	1.4	1.6	0.2
12	0.0	0.1	0.1	0.3	97.6	0.0	2.0
13	0.2	0.3	0.5	37.1	61.1	0.0	1.3
14	0.3	0.5	0.8	26.8	68.1	0.7	3.6
15	0.1	0.5	0.6	40.0	58.2	0.0	1.2
16	0.3	1.0	1.3	39.3	58.8	0.0	0.6
17	0.1	0.3	0.4	0.9	94.7	0.0	4.0
18	0.3	1.0	1.3	13.0	84.8	0.0	0.9
19	0.5	0.9	1.4	31.7	66.2	0.7	0.0
20	1.1	1.8	2.9	54.0	41.4	0.4	1.3
21	2.5	3.2	5.7	33.7	60.6	0.0	0.0
22	9.1	16.2	25.3	72.5	1.2	0.2	0.8
23	9.0	24.9	33.9	63.3	1.7	o.0	1.1
24	25.6	67.7	93.3	6.4	0.0	0.1	0.0
25	0.7	1.0	1.7	93.4	3.9	0.0	1.0
26	2.8	3.6	6.4	89.0	3.2	0.0	1.4
27	1.6	1.7	3.3	94.3	1.6	0.4	0.4
28	3.7	5.8	9.5	65.6	17.4	0.0	7.5

Table 31. Particle Size Distribution of Bottom Sediments for Illinois River During March 1983 (Percent by Weight)

Sediment Station	% Clay	% Silt	% Clay & Silt	% Sand	% Rock	% Detritus	% Shells
1	33.7	34.6	68.3	31.1	0.3	0.3	0.0
2	38.5	44.1	82.6	16.9	0.0	0.5	0.0
3	43.2	46.4	89.6	10.4	0.0	0.0	0.0
4	10.2	7.9	18.1	74.5	3.4	3.4	0.0
5	32.7	51.5	84.2	15.7	0.0	0.1	0.0
6	20.8	17.5	38.3	46.1	12.4	1.6	1.6
7	31.1	29.9	61.0	29.9	5.0	0.5	3.6
8	25.4	20.3	45.7	12.6	27.1	0.0	14.6
9	4.0	5.6	9.6	40.6	44.8	0.0	5.0
10	8.6	8.5	17.1	44.7	36.3	1.9	0.0
11	12.3	9.7	22.0	67.3	8.6	2.1	0.0
12	4.9	4.3	9.2	79.3	10.1	0.2	12.
13	0.5	0.8	1.3	45.6	51.5	0.0	1.6
14	1.8	2.2	4.0	67.5	22.8	0.0	5.7
15	0.7	1.1	1.8	69.6	28.3	0.0	0.3
16	1.9	2.1	4.0	68.6	27.4	0.0	0.0
17	0.7	1.5	2.2	10.0	83.4	0.0	9.4
18	1.2	1.9	3.1	0.8	57.7	0.0	38.4
19	0.0	1.0	1.0	22.2	73.0	0.0	3.8
20	1.8	2.2	4.0	90.4	5.3	0.0	0.3
21	2.6	3.1	5.7	66.3	26.6	0.0	1.4
22	15.2	14.2	29.4	69.4	1.1	0.1	0.0
23	22.7	37.1	59.8	40.2	0.0	0.0	0.0
24	37.7	60.4	98.1	1.9	0.0	0.0	0.0
25	0.0	0.1	0.1	99.6	0.2	0.0	0.1
26	6.1	4.7	10.8	85.9	1.0	0.0	2.3
27	0.1	0.3	0.4	99.2	0.3	0.0	0.1
28	0.9	1.5	2.4	55.6	39.9	0.0	2.1

During the sampling regime there was no evidence that sludge deposits accumulate along the river bank. This does not suggest that the CSOs have no impact on the bottom sediments. The average percentages of grease and oil, solids, and volatile solids are shown in table 32. Assuming that sediment stations 25, 26, 27, and 28 (located on the East Peoria side) represent background content, it appears from table 32 that elevated values occur at the following sediment stations in the vicinity of CSOs:

Elevated grease/oil	*Elevated volatile solids*
4	4
5	5
9	6
10	8
11	9
12	

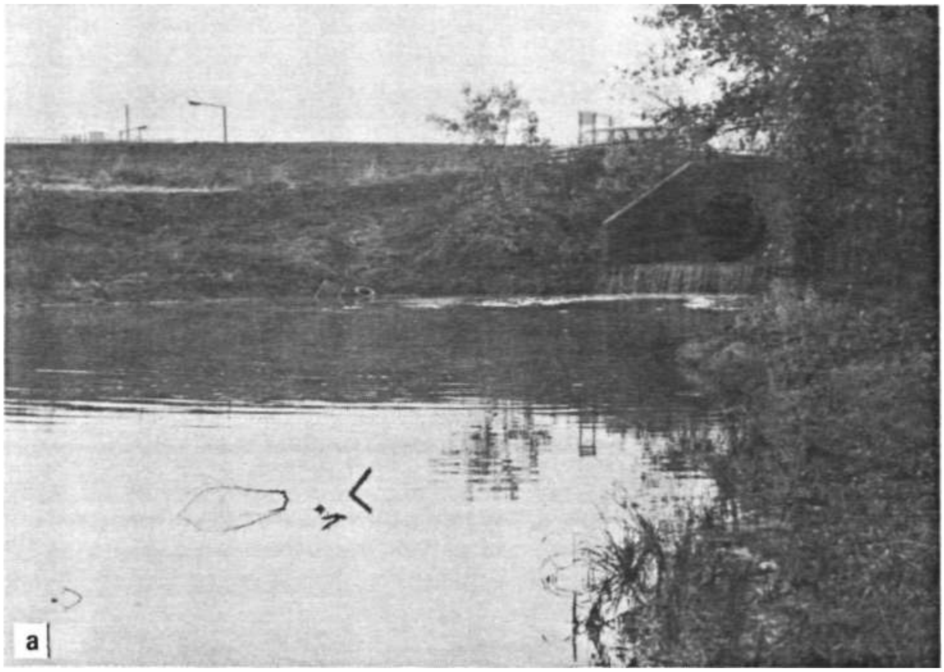
The percentages of grease and oil and volatile solids at the five stations on the East Peoria side of the river average about 0.07 and 0.9, respectively. Those at the sites listed above range from 0.21 to 0.70 percent grease and oil and 8.1 to 10.5 percent volatile solids. Interestingly, two sites above all CSOs (stations 2 and 3) on the Peoria side of the river showed elevated grease and oil content, and another upstream site (station 2) exhibited elevated volatile solids. It is most difficult to assess these "elevated sites" in terms of permissibility in the absence of sediment standards. Previous work by SWS suggests that bottom sediments in the river exhibiting a damaging effect on aquatic biota contain 13 to 20 percent volatile solids. This range was observed in the Brandon Road and Dresden Island pools of the waterway, which are located immediately below the combined sewer overflows and treated sewage outfalls serving the metropolitan Chicago area. Based solely on observations in these two navigation pools it is concluded that the CSOs at Peoria do impact bottom sediments at a limited number of sites in terms of grease and oil and volatile solids, but that the impact is not one of significant degradation.

A similar conclusion can be drawn from the data in table 32 relative to the percent solids of the bottom sediment. It has been the experience of SWS that streams receiving a constant supply of sewage solids maintain bottom sediments less than 50 percent solids. That is, the liquidity of the bottom sediments is substantially increased. In this regard, sediment stations 4, 5, and 6 in the vicinity of CSOs were marginal. The percent solids ranged from 43 to 48 percent.

The absence of sludge accumulations of sewage origin within the river is probably due to natural shoreline currents and wave action caused by boat traffic. The current and waves create sufficient scouring velocities to minimize solids buildup. In the absence of these currents and waves the potential for sludge accumulation is real. This reasoning is substantiated from observations made at the Darst Street CSO. Figures 4a and 4b depict the bay area arrangement into which CSO flows discharge. The bay area serves as a settling basin and significant quantities of settleable solids have accumulated in it, but the deposits do not extend to the river. There

Table 32. Values for Grease & Oil, Solids and Volatile Solids in Sediments of Illinois River (by dry weight)

Sediment Station	% Grease & Oil	% Solids	% Volatile Solids
1	0.10	63	3.9
2	0.38	52	9.3
3	0.21	50	5.9
4	0.62	48	10.5
5	0.70	43	9.7
6	0.18	48	8.4
7	0.08	70	4.9
8	0.09	74	9.5
9	0.21	75	8.1
10	0.33	76	4.0
11	0.30	66	5.9
12	0.22	85	2.9
13	0.06	89	0.9
14	0.05	85	2.9
15	0.10	88	2.1
16	0.05	82	4.1
17	0.05	93	0.9
18	0.03	95	0.9
19	0.09	89	3.0
20	0.05	83	2.9
21	0.14	86	3.3
22	0.08	66	3.6
23	0.06	71	2.7
24	0.04	61	3.7
25	0.05	84	0.5
26	0.07	80	1.8
27	0.10	83	0.4
28	0.04	84	1.7



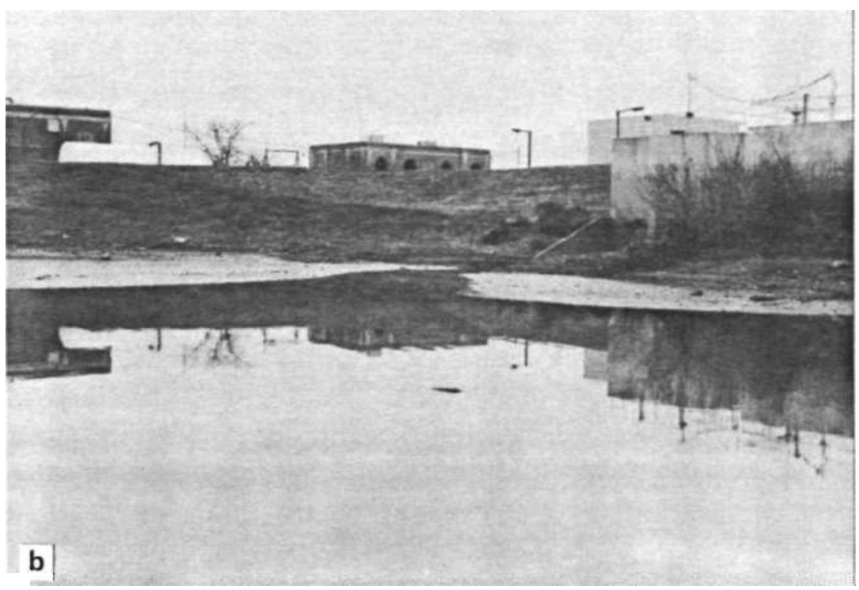


Figure 4. Darst Street a) overflew and b) bay area

are also some shoreline problems where CSOs are discharged sufficiently far from the river that overland flow exists. The CSO at Green Street, shown in figure 5, is typical of conditions at Morgan and South Streets. Although the influence of the CSOs on the waters of the river at these locations is imperceptible, nevertheless there is an accumulation along the shoreline of odorous sediments, fecal matter, paper items, etc. after each overflow event. From an aesthetic and public nuisance standpoint these are undesirable conditions incompatible with recreational activities and riverfront development.

Heavy Metal Content. The bottom sediment samples were examined for concentrations of cadmium (Cd), copper (Cu), lead (Pb), and zinc (Zn). Previous discussion has outlined the likely sources of these heavy metals in a drainage system. The purpose here is to present the results regarding heavy metal concentrations found in the bottom sediments during the course of the study and compare them with the findings of others who have investigated bottom sediments of streams and lakes.

Mean values for heavy metal concentrations are shown in table 33. With reference to the values for cadmium as shown in the table it is quite apparent that concentrations at five sampling locations differ significantly from and are greater than those at the other 23 locations. These differences are as follows:

Stations	*Bange of Cd (mg/kg)*
(a) 2, 3, 4, 5, 6	4.1 to 6.5
(b) All 23 others	0.5 to 2.2

Sediment stations 2 and 3 are located in lower Peoria Lake upstream of all CSOs. Stations 4, 5, and 6 are in the vicinity of CSOs.

There is a similar pattern though not as clear-cut for copper concentrations. There are seven sediment stations with copper levels that appear to be higher than background levels. The groupings are as follows:

Stations	*Range of Cu (mg/kg)*
(a) 2, 4, 5, 6, 10, 20, 22	30 to 68
(b) All 21 others	5 to 24

Station 2 is upstream of all CSOs while the rest of the six stations with elevated copper levels are within the vicinity of CSOs,

Elevated average concentrations of lead and zinc in the vicinity of CSOs were more prevalent than those noted for cadmium and copper. On the basis of the concentrations observed in sediments not likely to be influenced by CSOs, the lead levels average about 30 mg/kg. Average lead levels at seven stations in the vicinity of CSOs ranged from 106 to 298 mg/kg. Levels at all the other 12 stations in the vicinity of CSOs ranged from 17 to 77 mg/kg. One station upstream of all CSOs averaged 450 mg/kg — the highest level for lead recorded.

Figure 5. Green Street combined sewer overflow

Table 33. Mean Values for Concentrations of Metals in Sediments of Illinois River (mg/kg)

Sediment Stations	Cadmium	Copper	Lead	Zinc
1	2.1	14.9	46	140
2	5.1	30.3	450	481
3	4.1	21.8	59	232
4	6.5	54.9	260	456
5	5.0	67.6	245	401
6	5.9	46.0	115	360
7	1.8	13.9	40	109
8	2.3	15.3	49	115
9	1.8	9.6	106	129
10	2.0	36.9	298	198
11	2.2	24.0	254	195
12	1.6	13.3	59	87
13	1.0	9.5	22	67
14	1.4	9.8	53	109
15	1.0	5.5	77	165
16	1.8	12.3	59	141
17	0.8	3.9	49	48
18	1.0	10.0	17	39
19	2.5	16.3	70	106
20	2.4	34.9	62	297
21	2.2	21.5	121	330
22	2.1	31.3	49	123
23	0.9	9.0	21	54
24	2.0	15.5	34	80
25	0.6	5.7	14	17
26	1.6	8.5	36	50
27	0.5	4.7	12	25
28	2.0	6.9	17	39

The zinc levels here considered for background purposes averaged about 44 mg/l. A review of table 33 shows that only four sediment stations (12, 13, 17, and 18) upstream of or within the influence of CSOs had concentrations of zinc less than 100 mg/kg. The range for these stations is 39 to 87 mg/kg. Fifteen of 19 stations in the vicinity of CSOs exceeded 100 mg/kg zinc with a range of 106 to 456 mg/kg.

Several questions develop as the data are reviewed. Is there a relationship between heavy metal concentrations and the physical makeup of the sediment, i.e., percent clay, silt, sand and gravel? Are the elevated levels for the metals observed in the sediments due solely to CSOs? How do the concentrations of metals in the sediments investigated during this study compare with the findings of other workers? Is there likely to be an impact on the aquatic inhabitants of the river due to elevated metal concentrations in the sediment?

Generally the concentrations of metals in aquatic sediments are associated with the silt and clay fraction. A comparison of the concentrations of cadmium with the particle size distribution of the sediments suggests that this relationship does not apply here. The following summarizes the relationships for two different sampling periods:

	July 1982		*March 1983*	
Sediment station	*Sediment type*	*Cd conc.*	*Sediment type*	*Cd conc,*
2	Sand	5.6	Clay & silt	4.6
3	Clay & silt	3.9	Clay & silt	4.3
4	Clay S silt	6.5	Sand	6,4
5	Clay S silt	5.5	Clay & silt	4.4
6	Clay & silt	4.9	Sand & gravel	6.9

For the samples from these five stations, the only ones of 28 samples with elevated cadmium concentrations, it did not make any difference whether or not the sediment was predominantly silt and clay, sand, or sand and gravel. Also, because two of the stations (2 and 3) are located upstream of all CSOs and the detection of elevated cadmium was limited solely to three CSO areas (4, 5, and 6), it is not likely that the elevated cadmium concentrations are due solely to CSOs. This view is somewhat substantiated by earlier work (1971) undertaken by Dr. B.J. Mathis and Dr. T.F. Cummings of Bradley University. They found maximum concentrations of cadmium at 12.1 mg/kg and 10.4 mg/kg in the vicinity of milepoints 167.0 and 163.8 with averages of 4.1 and 3.7 mg/kg respectively in 13 to 18 sediment samples. Milepoint 167.0 is located above the narrows in upper Peoria Lake, and milepoint 163.8 is located close to sediment station 4. It is conceivable that the higher cadmium concentrations detected during this study simply reflect an extension of the muds in Peoria Lake. They may also be due to industrial sources. As shown in figure 1 all of the five sediment stations except #4 are basically lake stations. But this reasoning does not explain the high levels at sediment station 4 which is located within a marina. The isolation of cadmium sources in a manner necessary to better explain elevated concentrations in the lake sediments and, indeed, in the marina sediments is beyond the scope of this work.

As mentioned earlier there are seven sediment stations with copper concentrations higher than background levels. Six of the stations are within the influence of CSOs and it is fair to say that these higher copper levels are the result of CSOs. Nevertheless all values were less than 100 mg/kg. On the basis of work performed by 1EPA on 63 lakes during the summer of 1979 it was concluded that copper concentrations of less than 100 mg/kg in lake sediments are considered average conditions. With this in mind, it can be seen that the impact of CSOs on the sediments of the river is not of major consequence.

As shown in table 33, the elevated levels of lead and zinc in the river sediments follow a similar pattern. That is, generally at sediment stations where higher levels of lead occur, so do higher levels of zinc. And as in the case of cadmium there was not any correlation between the concentrations of lead and zinc and the physical makeup of the sediments, i.e., percent silt, clay, sand, or rock. In fact since most of the sediment in the vicinity of CSOs is sand or a mixture of sand and rock, it is tempting to relate heavy metal accumulations, particularly zinc, to substrate other than clay and silt. A more logical explanation rests with the growth of benthic organic matter that is attached to the sand and rock. It is probable that the somewhat enriched bottom of the river in the vicinity of CSOs sustains biological organisms that have the capability to assimilate metals. As shown in table 32 there are more volatile solids associated with sand and rock (see table 31) than anticipated. Frequently sand and rock in CSO areas contain 4-8 percent volatile material. In the absence of sludge deposition this material is probably attached aquatic plant life. Its capability to "strip" heavy metals from overlying water is well documented.

As mentioned earlier, out of 19 sampled sediment stations within the influence of CSOs, 7 showed lead content in excess of 100 mg/kg. Fifteen of the 19 stations showed zinc concentrations in excess of 100 mg/kg. There is little doubt that the CSOs impact the sediments of the river in terms of lead and zinc. How significant is this impact?

A comparison of the lead and zinc results associated with the CSOs and the results for sediments examined by 1EPA in 63 Illinois lakes indicates that the sediment content in the river near-shore at Peoria is elevated or highly elevated. Is the comparison valid? Probably not. In the case of the lake study, most of the tributary flow is of rural origin. The sediments of the river near-shore at Peoria reflect urban influence. A recent study by the Northeastern Illinois Planning Commission (NIPC) on urban drainage as it affects a lake system (Lake Ellyn) provides some insight into the effects that a storm drainage system has on the sediments of a water body in the absence of sewage. The following are mean values (mg/kg) developed from six sediment samples for which heavy metal content was determined:

Lake Ellyn sediments

Cadmium	*Copper*	*Lead*	*Zinc*
5	144	1128	580

A review of these values for sediments influenced solely by urban drainage suggests two principal conclusions: 1) the metal content of sediments in a water body receiving drainage from an urban area will attain concentrations 2 to 3 times greater than non-urban sediments; and 2) a significant increase in metal content will occur in urban sediments in the absence of sewage. The NIPC study concluded that about 75 percent of the copper was derive'd from precipitation, dust, traffic, and soil erosion; about 88 percent of the lead from traffic; and about 70 percent of the zinc from precipitation, dust, traffic, and roof gutters. In light of these findings related to urban sediment, the lead and zinc concentrations in the sediments at near-shore Peoria are not unexpected.

What is the influence on the river's aquatic inhabitants of urban sediments with substantial quantities of metals in them? NIPC observed that certain aquatic life, namely fishes, are not limited by the presence of high concentrations of heavy metals in the sediment. Goldfish, carp, bluegill, and bass survive in Lake Ellyn. Species diversity is quite low but this is probably due more to limitations in habitat than to heavy metal content in the sediments.

The work by Mathis and Cummings was designed to quantify the relationship between heavy metals in the sediments of the Illinois river and bottom dwelling organisms (worms and clams) and fishes. There has been and continues to be speculation that heavy metals tend to accumulate at successive trophic levels in the food chain. These workers did not find that to be the case. Generally the metal concentration in the aquatic worms observed - was similar to that in the sediment for cadmium, copper, lead, and zinc. Cadmium and lead concentrations in clams were less than those observed in the worms, but copper and zinc concentrations were about the same. Contrary to some expectations, metals in fishes did not concentrate along successive trophic levels, and the concentrations were substantially less than observed in the sediment, worms, and clams.

In summary, a definitive relationship was not established between cadmium concentrations in the river's sediment and CSOs. In contrast, there is no doubt that CSOs do impact the near-shore sediments with regard to copper, lead, and zinc. It is quite likely some impacts will occur solely because of urban drainage in the absence of sewage flow. The study by Mathis and Cummings relative to metals in sediment and their relationship to aquatic organisms (worms and clams) suggests that bottom dwelling creatures tend to accumulate heavy metals in approximately the same concentration as that in their sediments. Fishes do not. The study by NIPC on urban sediments indicates that fishes survive and presumably propagate in the presence of sediments with highly elevated concentrations of the metals here discussed. In general there is not adequate data to support the view that the heavy metal content (Cd, Cu, Pb, Zn) in the sediments is harmful to aquatic organisms. There is some meager data, here cited, that suggest that bottom dwelling organisms and fishes can tolerate sediments containing substantial quantities of metals. Except for the unresolved issue of the cadmium source(s), the influence of the CSOs on the concentrations of copper, lead, and zinc is not unexpected. In the absence of documented evidence to the contrary, this should not be considered a major factor in limiting the numbers of aquatic inhabitants nor their species diversity in the Illinois River.

Benthic Macroinvertebrates. Aquatic macroinvertebrates are defined as animals visible to the unaided eye and capable of being retained by a U.S. Standard No. 30 mesh sieve. These organisms are usually numerous and easily collected, and they often have a life cycle of a year or more. Benthic macroinvertebrates, being relatively stationary, tend to reflect the minimum environmental quality conditions at a given point in a stream. The standing macroinvertebrate community tends to represent the long-term summation of the physical and chemical aquatic environment. Disturbance of this community by poor water quality or by alterations to the benthic habitat may be detected by benthic sampling.

Sediment samples were collected during October 1982 at 19 stations for the examination of the macroinvertebrate inhabitants. The locations are shown in figures. 1 and 2. The number and type of organisms retrieved are listed in appendix C.

For the purpose of classifying the organisms in terms of their tolerance to environmental conditions, reliance was placed on a system used by the IEPA. This classification system assumes that organisms -may be intolerant, moderately tolerant, quite tolerant, and completely tolerant of pollution conditions. A serious flaw in the classification procedure is that it also assumes that the only limiting factor is water quality, while it is well known that other factors may be limiting. Principal among these is the type of habitat (sediment) available. Nevertheless the classification system was used as part of the data evaluation process in this study.

Of the 19 sampling stations selected, 3 were located upstream of all CSOs, 10 were located within the immediate influence of CSOs, 1 was located downstream of all CSOs, and 5 were located across the river on the East Peoria side. Listed in table 34 are the types of sediment observed at each station, the number of organisms retrieved, and their degree of tolerance to pollution. Also included *are* the total number of organisms retrieved per square meter of the river bottom as well as the different types (taxa) making up the community.

It is quite clear that most of the sediment in which the organisms dwell consists of sand or a mixture of sand and gravel. It is also quite clear that the preponderance of organisms are pollution tolerant. Although 13 taxa were retrieved during collections, the total number of taxa per station was limited to 2 to 5 with an average per station of 3.5. Five of the stations (9, 12, 13, 14, and 15) supported a density in excess of $1000/m^2$. The other 14 stations, on the average, supported a density of $344/m^2$. A close examination of the types of organisms making up the communities (see appendix C) shows that 80 to 100 percent of the total population at each station consists of midges (Chironomidae) and sludge worms (Tubificidae). These organisms are generally dominant in the Illinois Waterway throughout its length. In fact the densities of organisms and taxa noted at the 14 stations are not unlike those observed by SWS during 1979 in the LaGrange

Table 34. Benthic Macroinvertebrates

Benthos Station	Type of Sediment	Intolerant	Moderate	Facultative	Tolerant	Total Number Individuals per m^2	Total Number of Taxa	Location
1	Sand			64	701	765	4	
2	Sand		6	32	529	567	5	
3	Clay & silt			6	281	287	4	Upstream all CSOs
4	Clay & silt				466	466	3	
5	Clay & silt			6	102	108	3	
6	Gravel s sand			6	434	440	3	Within immediate influence of all CSOs
7	Gravel S sand			6	153	159	4	
8	Sand & gravel	6			860	866	4	
9	Gravel S sand			6	1046	1052	3	
10	Gravel S sand			6	254	260	5	
11	Sand S gravel				293	293	2	
12	Gravel & sand				1110	1110	5	
13	Sand S gravel				1632	1632	4	
14	Sand			6	2788	2794	5	
15	Clay & silt			19	2117	2136	3	Downstream all CSOs
16	Sand		6		178	184	3	East side of river
17	Sand				57	57	2	
18	Sand				280	280	2	
19	Sand				229	229	3	

pool. In that pool, located immediately downstream of the Peoria pool, the average density of benthic macroinvertebrates was $220/m^2$ with an average taxa per station of 3.8.

Of the five stations supporting densities in excess of $1000/m^2$, three (9, 12, and 13) are located in the immediate vicinity of CSOs, one (14) is on the Peoria side downstream of all CSOs, and the other one (15) is on the East Peoria side of the river. Although the number of organisms at these stations is higher than at the other 14 stations, the densities are not great enough to indicate the type of significant organic enrichment that has been observed by SWS in hundreds of thousands of tubificids in the enriched sediments in the Lockport and Dresden Island pools of the waterway.

Classically the effect of organic pollution on the benthic community is characterized by a sharp reduction in taxa and a corresponding rapid rise in population density. This was not evident from the collections made during this study. Rather the population densities and lower number of taxa are more suggestive of the effects of toxicants or habitat limitation. Since there were no collections completely devoid of macroinvertebrates, acute toxicity is not a prime consideration. This does not mean that low level chronic or selectively toxic substances are not present. However the weight of the evidence suggests that the limited density and taxa of the organisms are caused by an unstable habitat influenced by excessive wave action generated by boat traffic and wind.

The similarities in the composition of the benthic community and its diversity at locations upstream of all CSOs and within the influence of CSOs indicate that the influence of CSOs on the overlying water quality is not a limiting factor.

Sediment Oxygen Demand. The demand for oxygen exerted by aquatic sediments on the overlying water is known as sediment oxygen demand (SOD). In some cases, particularly during anoxic conditions, the demand may be caused by inorganic chemical reactions. But in-stream demand is generally caused by the respiration of benthic organisms such as bacteria, protozoa, periphyton, and macroinvertebrates.

Efforts to define SODs at selected locations during the course of this study relied upon two methods. One was an experimental procedure whereby sediments were delivered to the laboratory and attempts were made to isolate the principal fractions of SOD in terms of chemical and biological demand. Attempts were then made to further fractionate the defined biological demand into carbonaceous and nitrogenous demand. If this could have been done, a more definitive assessment would have been possible relative to the influence of CSO on the bottom sediments. Unfortunately the results were inconclusive and so are not reported here.

The other method, one developed by SWS, has been successfully used for the past 10 years on diverse bottom sediments throughout the state and particularly in the Illinois River. The procedure measures SOD of the sediments in place. Sufficient measurements have been recorded by this procedure to permit the classification of sediments in terms of environmental conditions. Table 35 summarizes the scheme that has been developed, in which the degree of sediment degradation is related to a range of SODs. This *in-situ* procedure was used to characterize the sediments at Peoria.

Nineteen stations were selected for examination. They were the same as those used for benthic macroinvertebrate evaluations. The values of SODs recorded are included in table 36 along with sediment classifications for each station. SOD values ranged from 0.70 to 3.12 grams/m^2/day. None of the sediments reflected a condition of sewage sludge or grossly polluted sediments. If the sediments upstream of all the CSOs and those on the east side of the river are considered background with an average SOD of 1.62 grams/m^2/day then the "normal" sediments of the area are slightly degraded. This is consistent with the value of 1.54 grams/m^2/day derived from measurements made throughout the Peoria pool by SWS several years ago.

Ten stations were located within the immediate influence of CSOs. Two of these are considered moderately clean (10 and 12) and three are considered slightly degraded (9, 11, and 13). In effect the sediments at these locations equal or are better than "normal" sediments in the area. The remaining five stations, on the other hand, reflect sediment conditions worse than normal. They include:

Moderately polluted	(4, 5, 6, 8)
Polluted	(7)

It is interesting that these sediments are located in continuity along the upper reaches of the CSO discharges — all above the Franklin Street bridge — and basically in the region of lower Peoria Lake, There are impacts on the near-shore sediments from CSOs in this region. In terms of SOD the impact is measurable. The average value for this area is 2,61 grams/m^2/day, representing moderately polluted conditions (see table 35).

Sewer Sampling

The on-shore work performed during the course of this study was the responsibility of Randolph and Associates, The work consisted principally of maintaining rain gages and recording rainfall, monitoring approaching storm events by radar facilities, measuring flows in sewers during storm events, and collecting samples at sequential intervals from those flows.

Rain gaging stations were located in the vicinity of Spring and Darst Streets and Fire Station No. 3 on Armstrong Avenue, basically the extremities of the combined sewer system. Nine sewers were selected for monitoring purposes, of which 8 were combined sewers and 1 was a storm sewer. The 8 combined sewers were selected on the basis that they probably discharged about 85 percent of the total flow from all CSOs during a storm event. Combined sewer overflows were measured and sampled during seven storm events. The dates, intensities, and durations of the storms as well as the number of samples collected from the sewers during each of these seven events are shown in table 5.

Table 35. Generalized Benthic Sediment Condition Characterized by SOD Rates

Generalized Benthic Sediment Condition	SOD Range at 25 C (grams/m^2/day)
Clean	<0.5
Moderately clean	0.5-1.0
Slightly degraded	1.0-2.0
Moderately polluted	2.0-3.0
Polluted	3.0-5.0
Grossly polluted	5.0-10.0
Sewage sludge-like	>10.0

Table 36. Sediment Oxygen Demand Rates

Benthos Station	SWS SOD Classification	SOD Value @ 25°C (grams/m^2/day)
1	Slightly degraded	1.52
2	Slightly degraded	1.96
3	Moderately polluted	2.86
4	Moderately polluted	2.63
5	Moderately polluted	2.64
6	Moderately polluted	2.15
7	Polluted	3.12
8	Moderately polluted	2.53
9	Slightly degraded	1.05
10	Moderately clean	0.86
11	Slightly degraded	1.15
12	Moderately clean	0.99
13	Slightly degraded	1.64
14	Moderately clean	0.70
15	Slightly degraded	1.57
16	Slightly degraded	1.03
17	Slightly degraded	1.26
18	Slightly degraded	1.09
19	Slightly degraded	1.37

Location
Upstream of all CSOs
Within the immediate influence of all CSOs
Downstream all CSOs
East side of river

Measurements of sewer overflows and corresponding rainfall were recorded during the period June 9 to December 5. The number of overflow events equal to or greater than 10,000 cubic feet for the 8 combined sewers varied from 17 to 32. On 17 occasions during the 6-month period all 8 combined sewers discharged during the same rainfall event. Data for all overflow events and rainfall measurements are included in appendix D, Also included in the appendix are the tabulated overflow and rainfall occurring on June 28, August 24, and September 17, 1982.

Rainfall Measurements. The operation of the rain gage network was a successful undertaking. Although the record is continuous for the course of the study period, only those rainfall data obtained during the sampling of sewers are discussed here. The data are summarized graphically in figures 6 and 7 for the seven storm events. A review of the figures reveals that each storm was different in terms of intensity and areal distribution. No typical storm was recorded.

Within the period June 9 to December 5 the total rainfall was 24.1 inches. This compares favorably with the historical record whereby, on the average, 21.2 inches of rainfall is likely to occur between June 1 and December 1 of any year.

On June 28 a storm of high intensity but short duration passed across the upper extremities of the CSO area. The sewer at Spring Street (see figure 1 and table 1) contained considerable flow, while the flow at Darst Street, located at the lower extremity of the CSO area, was relatively low. The river was sampled during this storm.

The storm on July 7 was well distributed over the area but its intensity and duration were moderate.

On July .18 two isolated storms occurred. These are designated as (1) and (2) in figures 6 and 7. A short low intensity storm was recorded during the morning hours; about three to four hours later a storm of moderate intensity passed across the area. Its duration was about four hours.

On August 7, 1982, a moderately intense storm of three hours duration was well distributed across the area.

The storm of August 24 occurred suddenly and was quite intense with a duration of about 90 minutes. The river was sampled during this storm.

The storm on September 17 was of low intensity, was well distributed, and lasted over three hours. The river was sampled during this event.

The November 1 storm was of moderate duration and intensity with slightly higher intensities at the upper end of the CSO area than at the lower end. Although it is not evident from the graph in figure 7, this particular storm did produce two separate overflow events with well-defined durations.

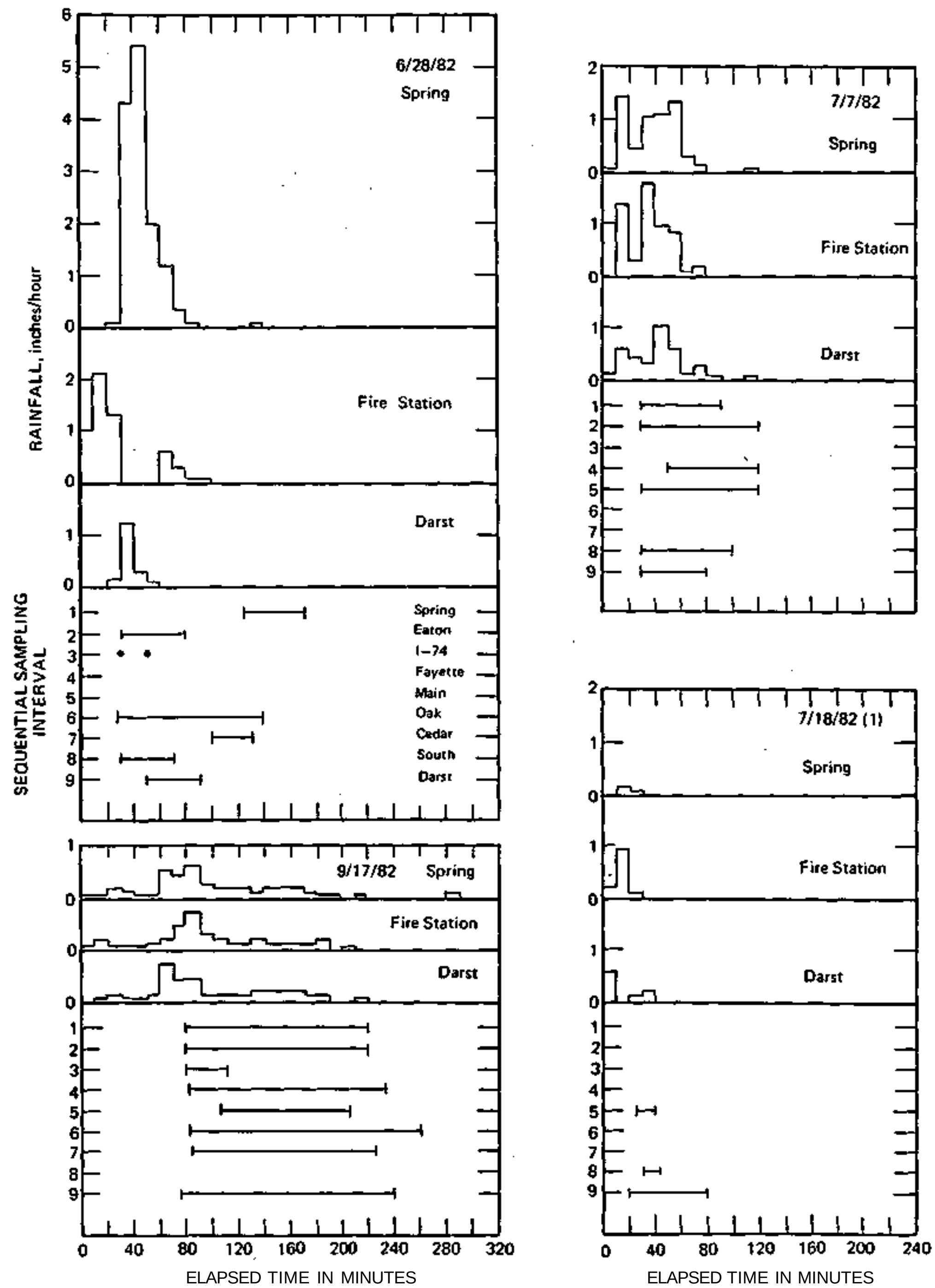


Figure 6. Rainfall intensities and sampling intervals, 6/28/82, 7/7/82, 7/18/82 (1), and 9/17/82

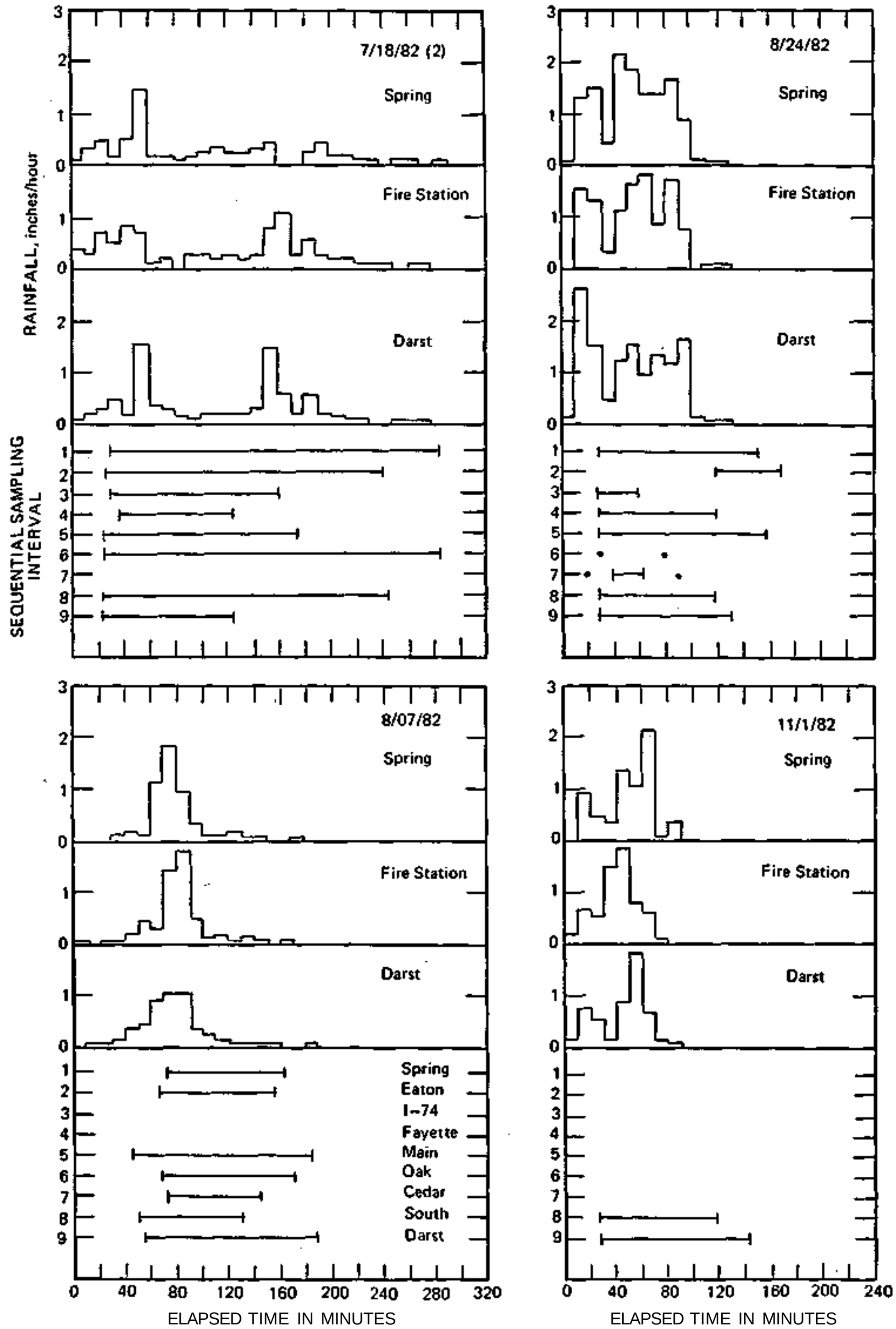


Figure 7. Rainfall intensities and sampling intervals, 7/18/82 (2), 8/7/82, 8/24/82, and 11/1/82

Also included in figures 6 and 7 are the sampling intervals that were used for evaluating the quality of the sewer flow for each storm event at each of the nine sewers. This will be discussed in more detail later in this report.

The storms occurring during the sampling of the Illinois River (June 28, August 24, September 17) were three dissimilar events. This presented opportunities to assess the effects of the CSOs on the water quality of the river over a range of rainfall intensities, durations, and areal distributions.

Sewer Overflow Measurements. The computerized flow measurement system functioned well and produced good results. The data developed were particularly useful for estimating the relative contribution of each of the CSOs monitored to the total quantity of overflow discharged to the river during storm events. Typical hydrographs during various storm events are shown in figures 8 and 9 for the combined sewers at Spring Street and Darst Street, respectively. The hydrograph for Darst Street depicted in figure 9 for the November 1 storm event represents only the first overflow event that occurred on that date. Figure 10 depicts hydrographs for all sewers except the one at South Street for the September 17 storm event.

With reference to figures 8 and 9 for the June 28 storm, it is obvious from the hydrographs for Spring Street and Darst Street sewers that the areal distribution of the storm weighed more heavily at Spring Street than at Darst Street. During that storm event the maximum rate of flow in the sewer at Spring Street was about 190 cfs while at Darst Street it was about 70 cfs.

The durations of seven overflow events for those sewers sampled are shown in table 37. On the average and excluding the initial overflow occurrence for the July 18 storm and the 1-74 storm sewer, the duration of overflows ranged from about 150 minutes at South Street to about 225 minutes at Darst Street.

The overall quantities of CSOs measured for the seven events are summarized in table 38. It is quite apparent, as expected, that considerable variations in overflow volume occur for different storms as well as between each sewer for the same storm. This is more clearly shown in table 39 where the percent contribution to the total overflow for each sewer is summarized. The major CSO in terms of quantity of discharge is Darst Street during most storms. Obviously this will be dependent on the areal distribution of a storm event, but during the course of this study between 35 to 65 percent of the total overflow was contributed by the CSO at Darst Street except during the June 28 storm event. The 1-74 storm sewer is of minor importance in terms of quantity. The CSO at Cedar Street ranked second to that at Darst Street.

Previous estimates, based on a mathematical model, have been made of the likely contribution of various combined sewers serving the city. A comparison of these estimates with observations made during this study is shown in table 40. Assuming that the values developed during this study are reasonable, the data show differences. Some of these differences may be attri-

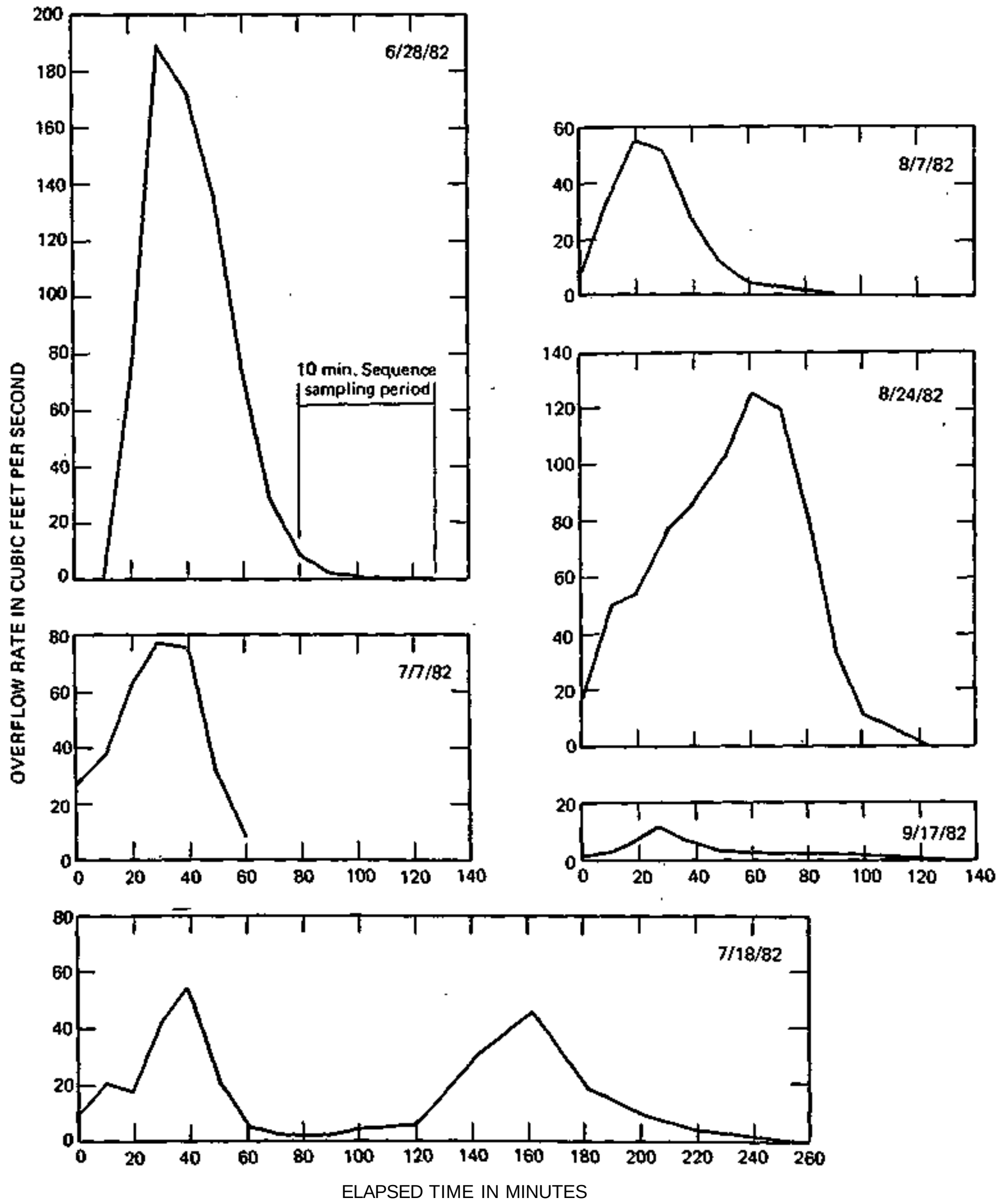


Figure 8. Overflow rates at Spring Street by date

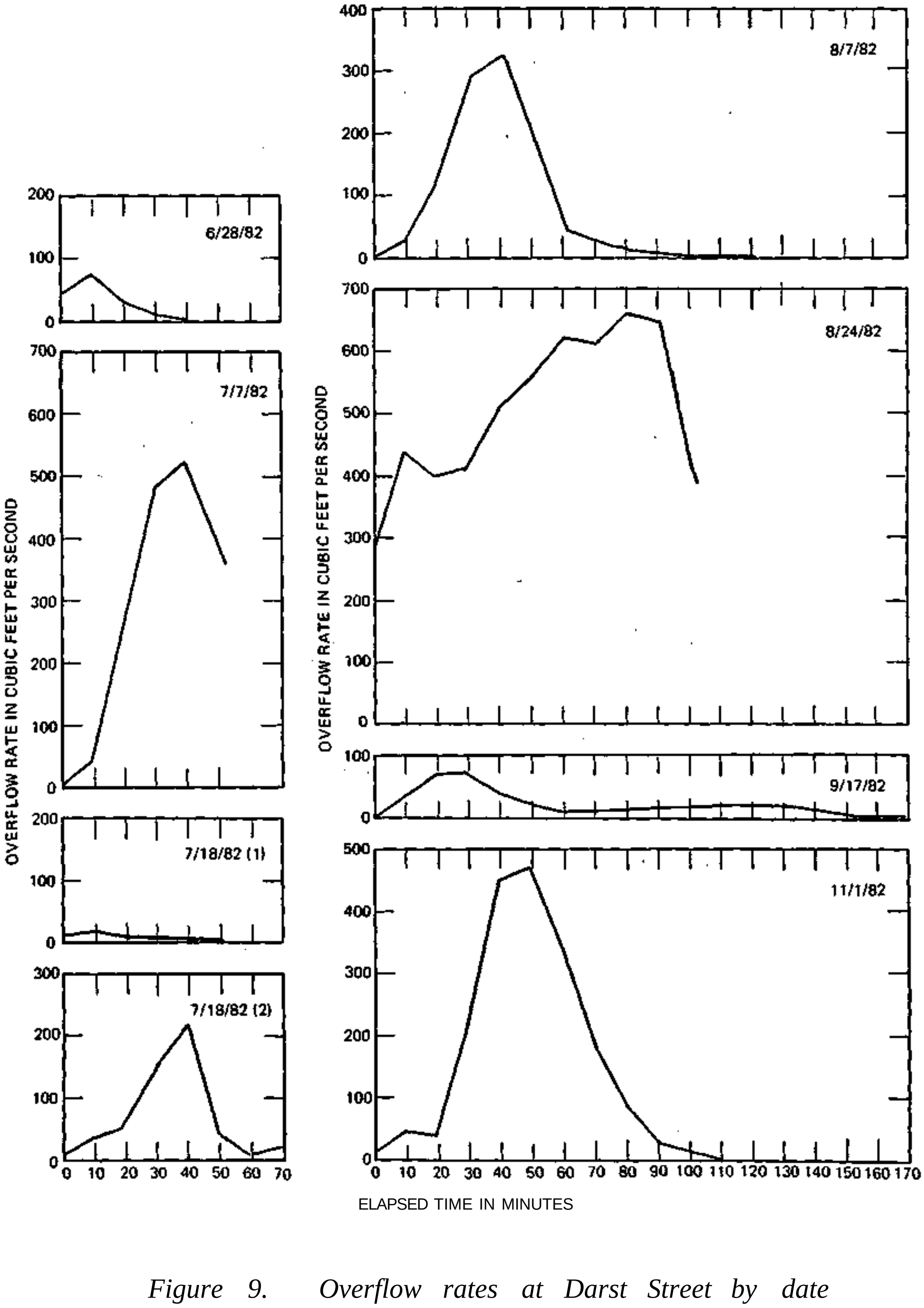


Figure 9. Overflow rates at Darst Street by date

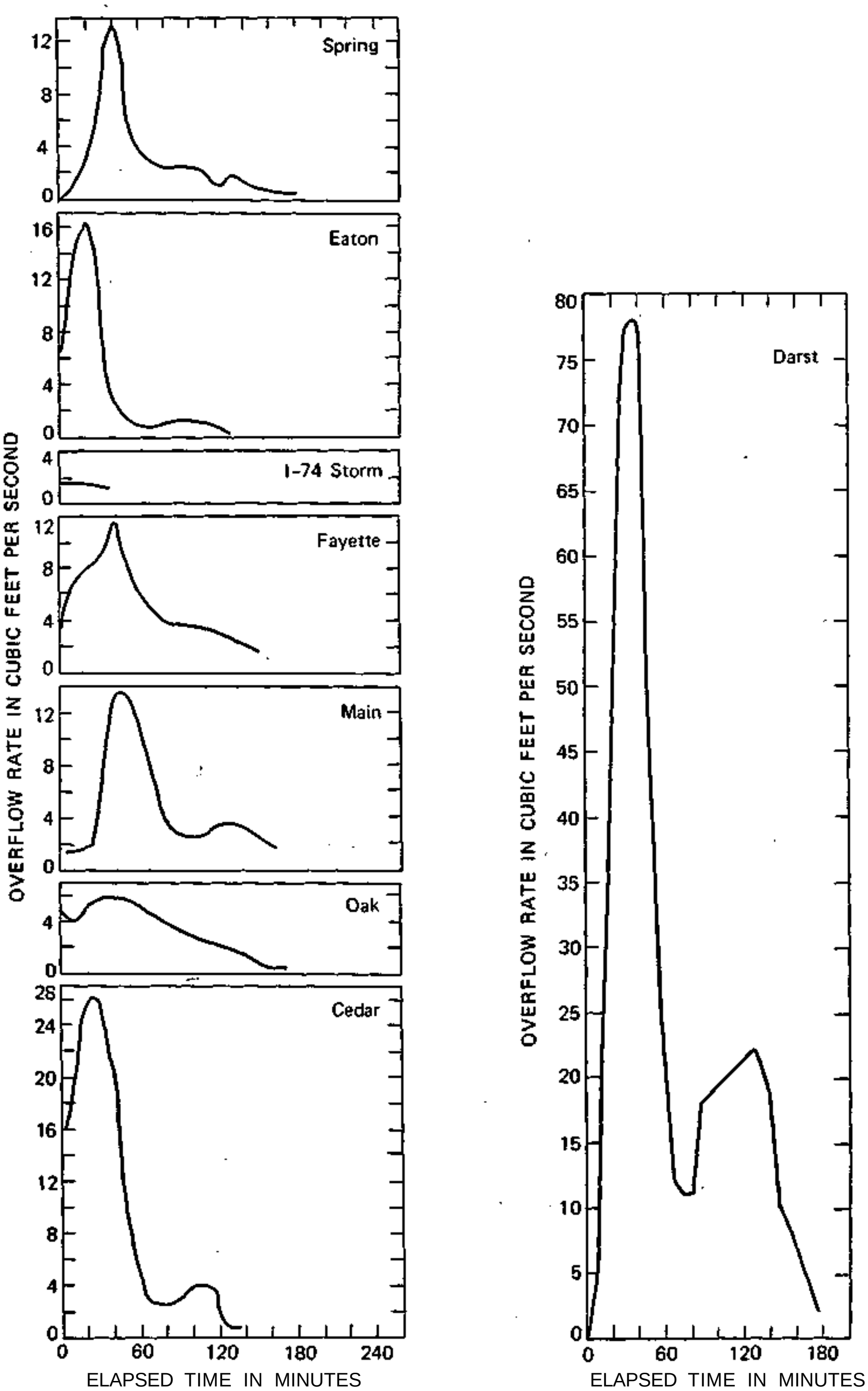


Figure 10. Overflow rates, September 17, 1982

Table 37. Sewer Overflow Duration Per Event

Event	Sewer Overflow Duration in Minutes								
	Spring	Eaton	1-74	Fayette	Main	Oak	Cedar	South	Darst
6/28/82	140	110	160	130	170	170	120	110	140
7/07/82	130	110	80	100	110	170	120	110	160
CD 7/18/82	0	40	20	20	50	80	60	40	110
(2) 7/18/82	360	250	230	360	300	400	280	260	330
8/07/82	140	120	100	170	180	180	120	130	210
8/24/82	180	210	120	210	210	210	180	170	210
9/i7/82	190	150	170	270	220	270	170	180	290
(1) 11/1/82	180	180	100	170	80	130	150	130	180
(2) 11/1/82	150	100	100	180	110	170	130	130	170

Table 38. Overflow Volumes Produced for Durations Included in Table 37

Event	Overflow Volume in Cubic Feet (ft^3)									
	spring	Eaton	1-74	Fayette	Main	Oak	Cedar	South	Darst	Total
6/28/82	387,856	132,660	18,861	142,963	88,400	82,677	449,446	94,050	79,128	1,476,041
7/07/82	179,400	135,135	9,227	93,600	65,010	122,967	413,889	132,880	1,104,282	2,256,390
(1) 7/18/82	0	768	40	40	4,300	533	8,280	1,920	30,140	46,021
(2) 7/18/82	253,946	199,558	13,805	199,245	135,755	164,839	522,596	197,138	969,676	2,656,558
8/07/82	111,552	104,178	9,436	108,590	93,431	88,617	313,865	112,933	821,577	1,764,179
8/24/82	441,436	373,705	33,397	349,879	271,186	359,902	1,348,636	436,050	3,450,911	7,065,102
9/17/82	29,469	32,513	4,080	47,964	47,348	37,086	80,637	70,371	258,854	608,322
(1) 11/1/82	123,632	157,396	24,709	120,190	2,613	169,706	521,100	139,620	1,085,343	2,344,309
(2) 11/1/82	84,263	38,236	6,709	35,526	38,390	46,693	150,651	71,515	426,587	898,570
Total	1,611,554	1,174,149	120,264	1,097,997	746,433	1,073,020	3,809,100	1,256,477	8,226,498	19,115,492

Table 39. Percentage Overflow Contribution by Sewer*

Event	Spring	Eaton	1-74	Fayette	Main	Oak	Cedar	South	Darst
	Percentage Contribution								
6/28/82	26.28	8.99	1.28	9.69	5.99	5.60-	30.45	6.36	5.36
7/07/82	7.95	5.99	0.41	4.15	2.88	5.45	18.34	5.89	48.94
(1) 7/18/82	0	1.67	0.04	0.09	9.35	1.37	17.99	4.19	65.49
(2) 7/18/82	9.56	7.51	0.52	7.50	5.11	.6.20	19.67	7.42	36.5.1
8/07/82	6.32	5.90	0.53	6.16	5.29	5.0,1	17.79	6.41	46.57
8/24/82	6.25	5.29	0.47	4.95	3.84	5.09	19.09	6.17	48.85
9/17/82	4.84	5.35	0.67	7.88	7.78	6.11	13.26	11.57	42.56
(1) 11/1/82	5.27	6.71	1.05	5.13	0.11	7.24	22.23	5.96	46.30
(2) 11/1/82	9.38	4.26	0.75	3.9	4.27	5.20	16.77	7.96	47.47

* Based on listed 9 outfalls as 100%

Note: (1) & (2) mean two separate overflow events

Table 40. Comparison of Observed Percentage Contributions to Historical Estimates

Sewer	Percentage Contributions*		
	1.56-inch Rain		All monitored
	Estimated	1982 observed**	1982 storms
Spring	15.14	6.25	8.43
Eaton	5.34	5.29	6.14
Fayette	12.71	4.95	5.74
Main	5.08	3.84	3.90
Oak	5.90	5.09	5.6l
Cedar	25.4.2	19.09	19.92
South	4.74	6.17	6.57
Darst	25.67	48.85	43.05
1-74 Storm	—	0.47	0.64

* Based on listed 9 outfalls as 100%
**Based on 8/24/82 storm

butable to interim changes in the drainage system and variations in regulator adjustments.

On the basis of a facilities planning report previously developed for the city, the drainage area being served by the seven CSOs monitored during this study serves about 85 percent of the total drainage area tributary to the combined sewer systems. This relationship was used to project the total overflow from all combined sewers on the basis of measurements at the eight selected CSOs. For example, the volume of CSOs discharged to the river from the eight sewers monitored during the August 24 storm (excluding the 1-74 CSOs) was 7,031,705 cubic feet. The estimated total volume from all the CSOs is estimated to be 8,272,593 cubic feet (7,031,705 x 100/85). This method was used to determine the dilution afforded by the river during certain CSO events as well as to estimate loads applied to the river. The results will be discussed later.

Sewer Overflow Quality. The samples collected from the CSOs were examined for pH, 5-day biochemical oxygen demand (BOD_5), ammonia-nitrogen (NH_3-N), total suspended solids (TSS), settleable solids, volatile settleable solids, cadmium, copper, lead, zinc, and fecal coliform. The results of analyses performed during the storm events on June 28, August 24, and September 17 are included in appendix E. Considering the magnitude of the sampling endeavor, the complexity of the CSO system, and the variability of the storm patterns, a sufficiently large and reasonable data base was produced that permitted a rational assessment of the quality characteristics of the CSOs. For the most part samples were collected successfully at the planned interval of sequential sampling, i.e., 10 to 20 minute intervals. Where gaps did occur the collections at Darst Street provided excellent sampling sequences which permitted the development of reasonable values for other locations when deemed necessary. In the case of the CSOs at Cedar Street, any estimates required were developed from the relationships of flow and load determined from data gathered at Darst Street. For other CSO locations, regression techniques were used whereby the data for Darst Street were the independent variable. The resultant regression equations were used to estimate loads at other locations when required. Data for all storms except the storm event on November 1 were used in the evaluative process for estimating loads to the river. During the November 1 event the collection of samples for analyses was limited to CSOs at Darst and South Streets.

The results derived during the September 17 storm are the most complete in terms of sampling and analyses. The characteristics of the overflows for all CSOs except South Street are shown in figures 11 through 20, This series of figures demonstrates the magnitude of concentrations and loads released from seven different combined sewers and the differences in the release patterns between sewers for the same constituents — all during the same storm.

There is a concept concerning "first flush" that is generally applied to combined sewer systems. First flush as used here implies that the initial flows in a CSO are coincident with the maximum loads and concentrations of pollutants. A review of figures 11 through 20 suggests that the first flush concept is likely applicable for the CSOs that occurred on September 17 at Spring, Eaton, Cedar, and Darst streets but not at Fayette, Main, and Oak streets. For all constituents for which analyses were performed, except fecal coliform concentrations, there appears to be some predictability for the September 17 storm if this grouping of the sewers is considered. No predictability is possible for fecal coliform, as shown in figure 20.

Figures 21 through 40 demonstrate the magnitude of concentrations and loads released from two different combined sewers and the differences in release patterns between sewers for the same constituents — all for a series of different storms. Figures 21 through 30 include patterns for the CSO at Spring Street; figures 31 through 40 contain similar information for the CSO at Darst Street. A review of these figures indicates that release patterns differ for differing constituents (BOD_5, NH_3-N, TSS, etc.), and that release patterns and the magnitude of loads vary with differing storm events.

It was not the purpose of this study to examine in detail the applicability of the first flush concept or to scrutinize the temporal releases of pollutional substances in the CSOs. Rather the principal purpose for collecting sewer overflow quality information was to estimate the loads of pollutional constituents being discharged from the CSOs and to evaluate the impact of those loads on the water quality of the river. Nevertheless, the data developed from the sequential sampling of the CSOs as depicted in the numerous figures here demonstrate the inadvisability of relying on a single conceptual model for developing remedial measures. Ideal patterns of release or magnitudes of concentration or load do not exist for the CSO system at Peoria. Only by site-specific evaluations, such as those undertaken for the sewer system during this study, can insight be gained that in turn may be confidently applied for remedial purposes.

Loads Applied to River. The total estimated loads of BOD_5, NH_3-N, TSS, Cu, Pb, and Zn that were emitted from all the eight CSOs during six storm events are summarized in table 41. Also included in the table are the volumes of settleable solids and volatile settleable solids similarly discharged. With the exception of the August 24 event the poundage discharged for each event was within relatively narrow limits despite significant differences in the rainfall intensities and total rainfall recorded for each event. Excluding values for the August 24 event the following are the ranges observed:

Total rainfall (inches)	*BOD_5 (lbs)*	*NH_3-N (lbs)*	*TSS* (lbs)*	*Cu (lbs)*	*Pb (lbs)*	*Zn (lbs)*
0.64-1.34	4200-6500	52-101	49,000-59,000	8-14	12-28	18-40

* Excludes 9/17 value of 16,200 lbs

The August 24 storm with a duration of about 90 minutes and a total rainfall of 2.08 inches is one that is likely to occur once in ten years in Peoria. During that event the quantities discharged from the eight sewers were estimated. The estimates are shown at the top of page 108.

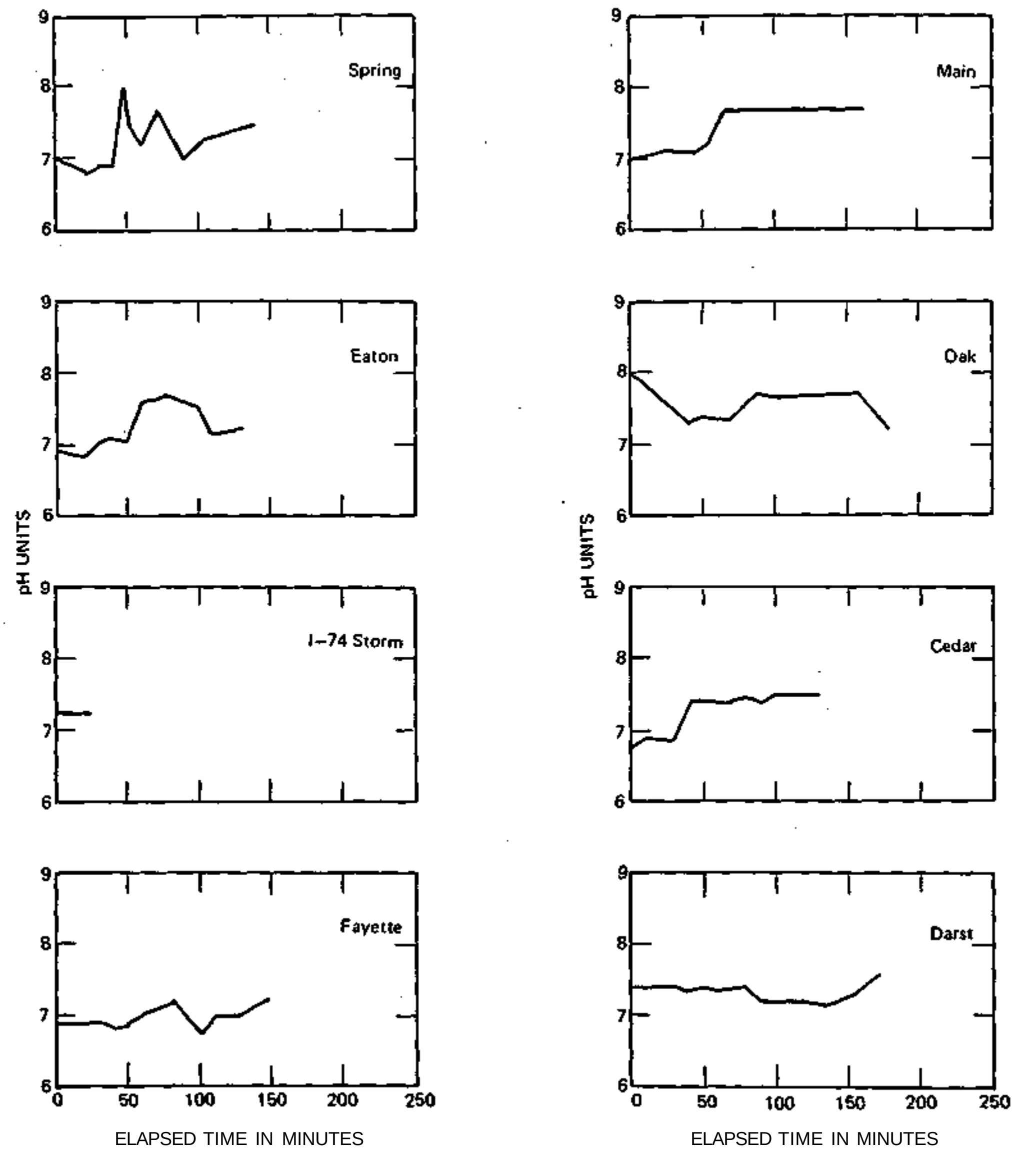


Figure 11. pH values, September 17, 1982

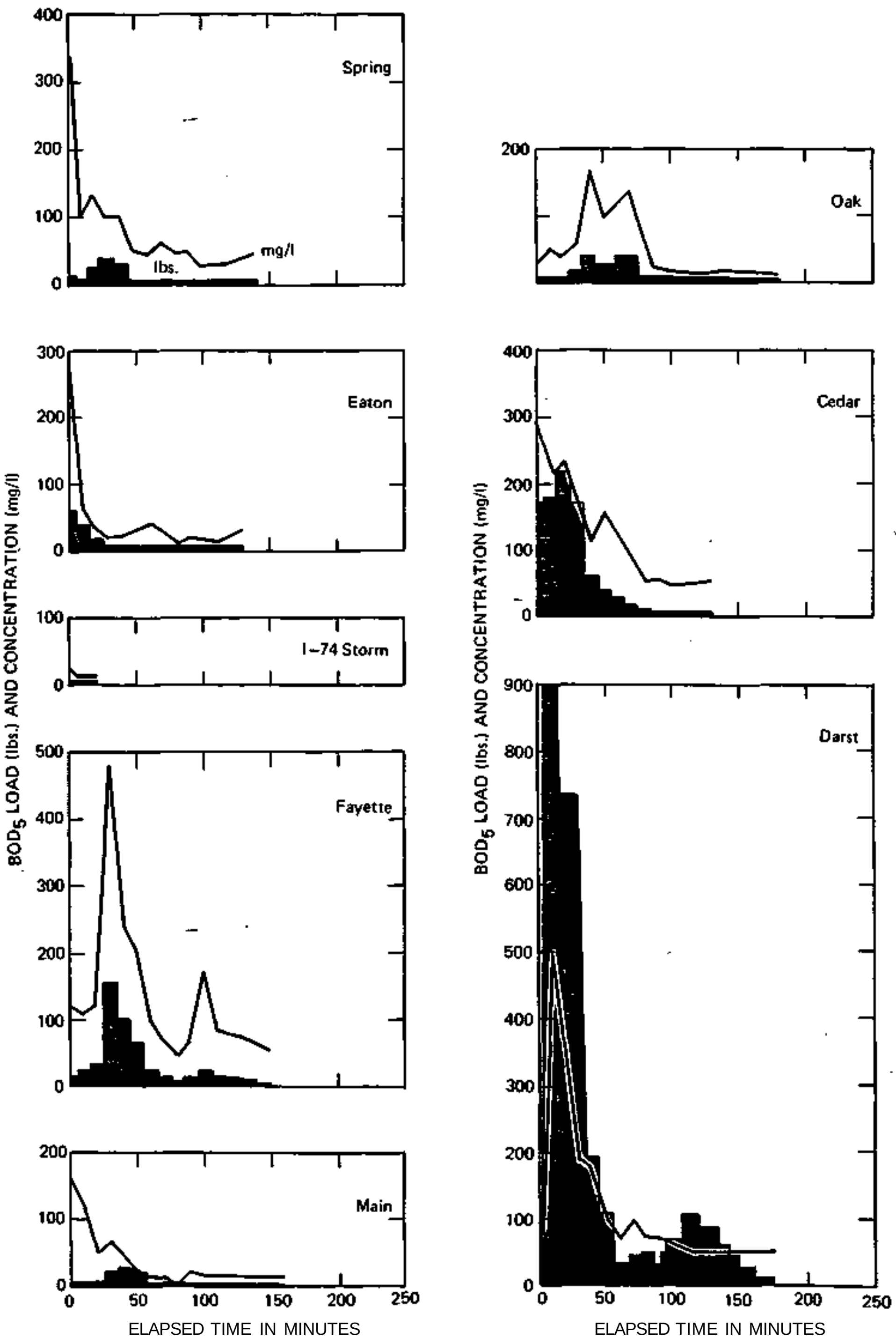


Figure 12. 5-day BOD loads and concentrations, September 17, 1982

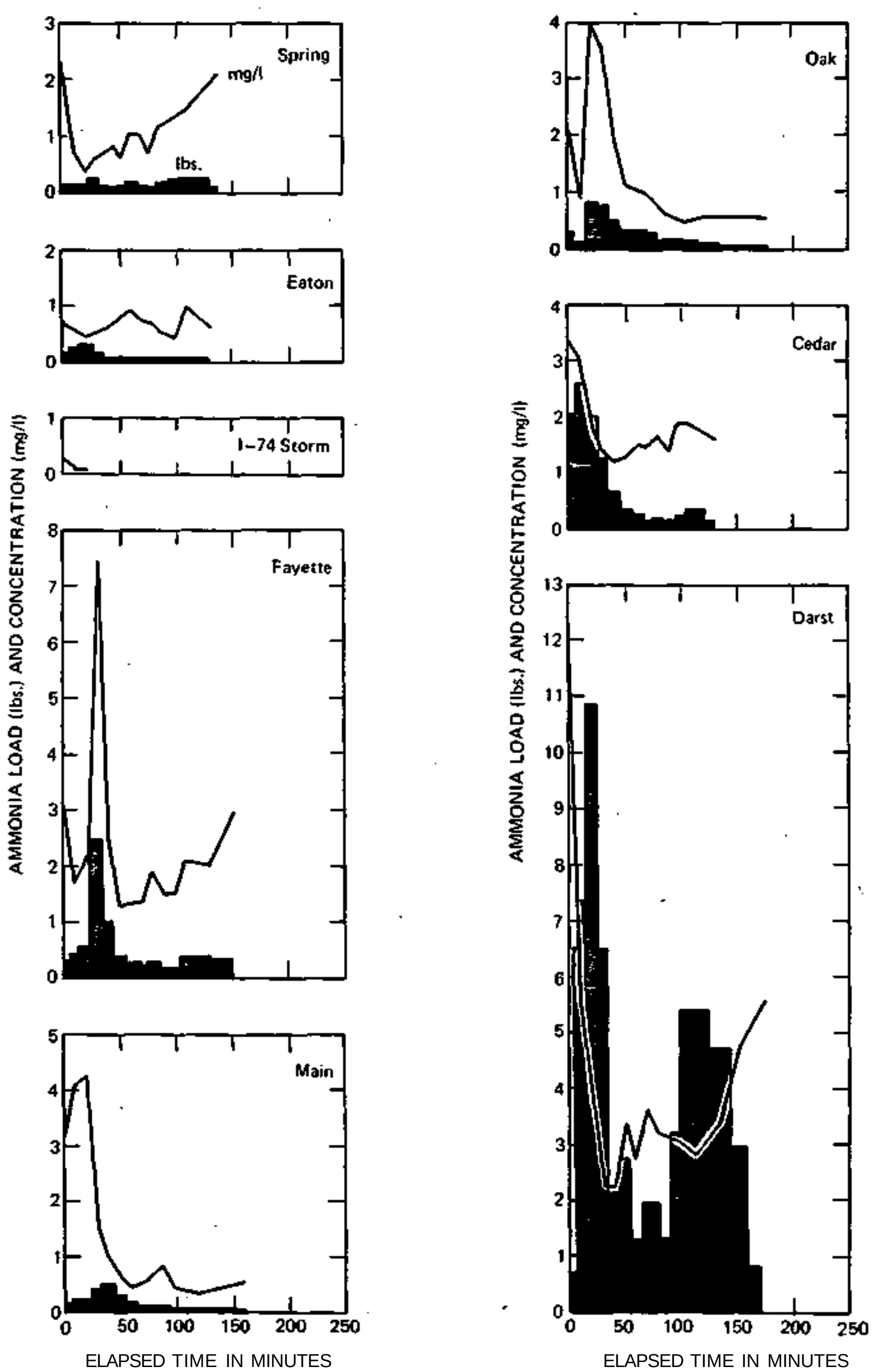


Figure 13. Ammonia loads and concentrations, September 17, 1982

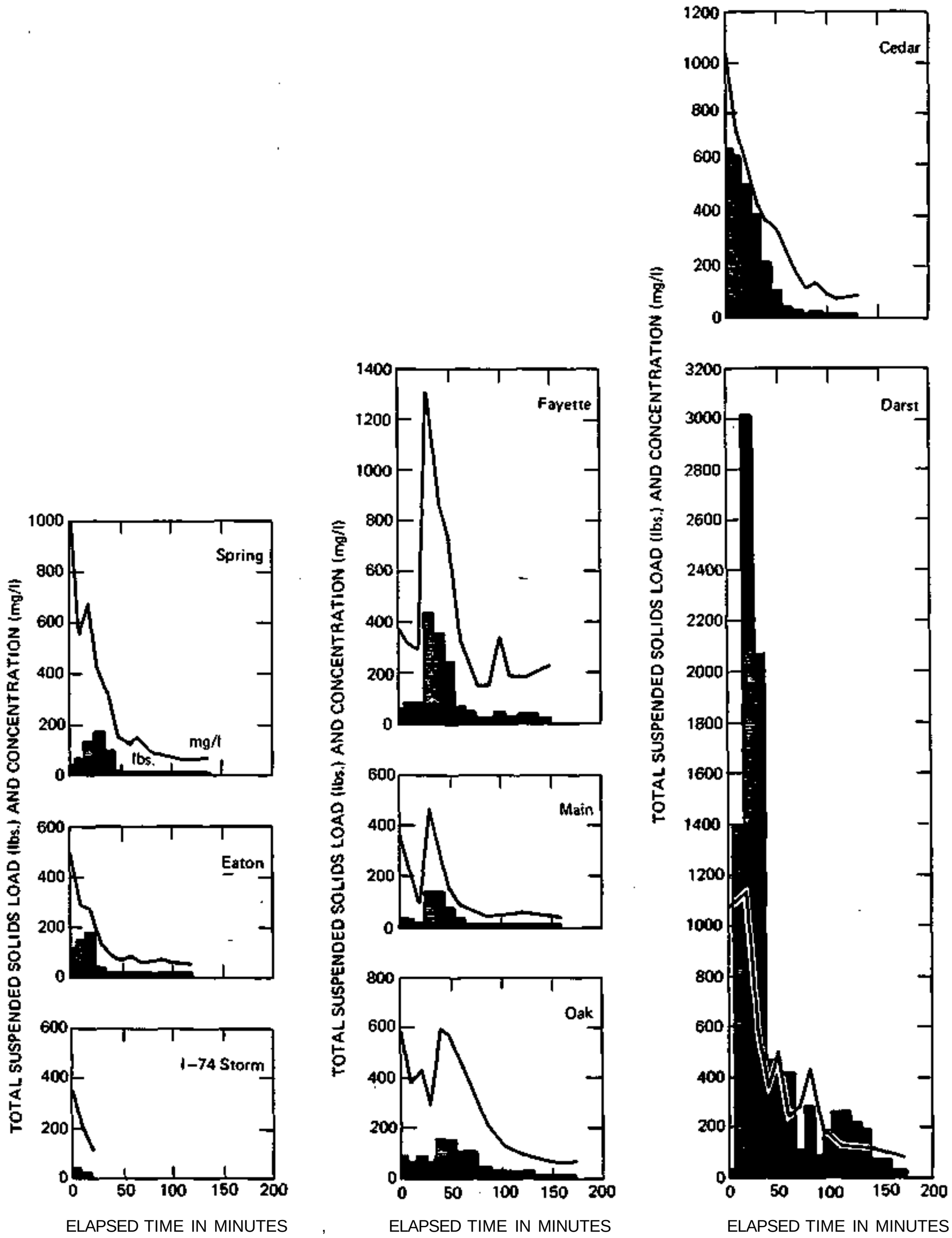


Figure 14. Total suspended solids loads and concentrations, September 17, 1982

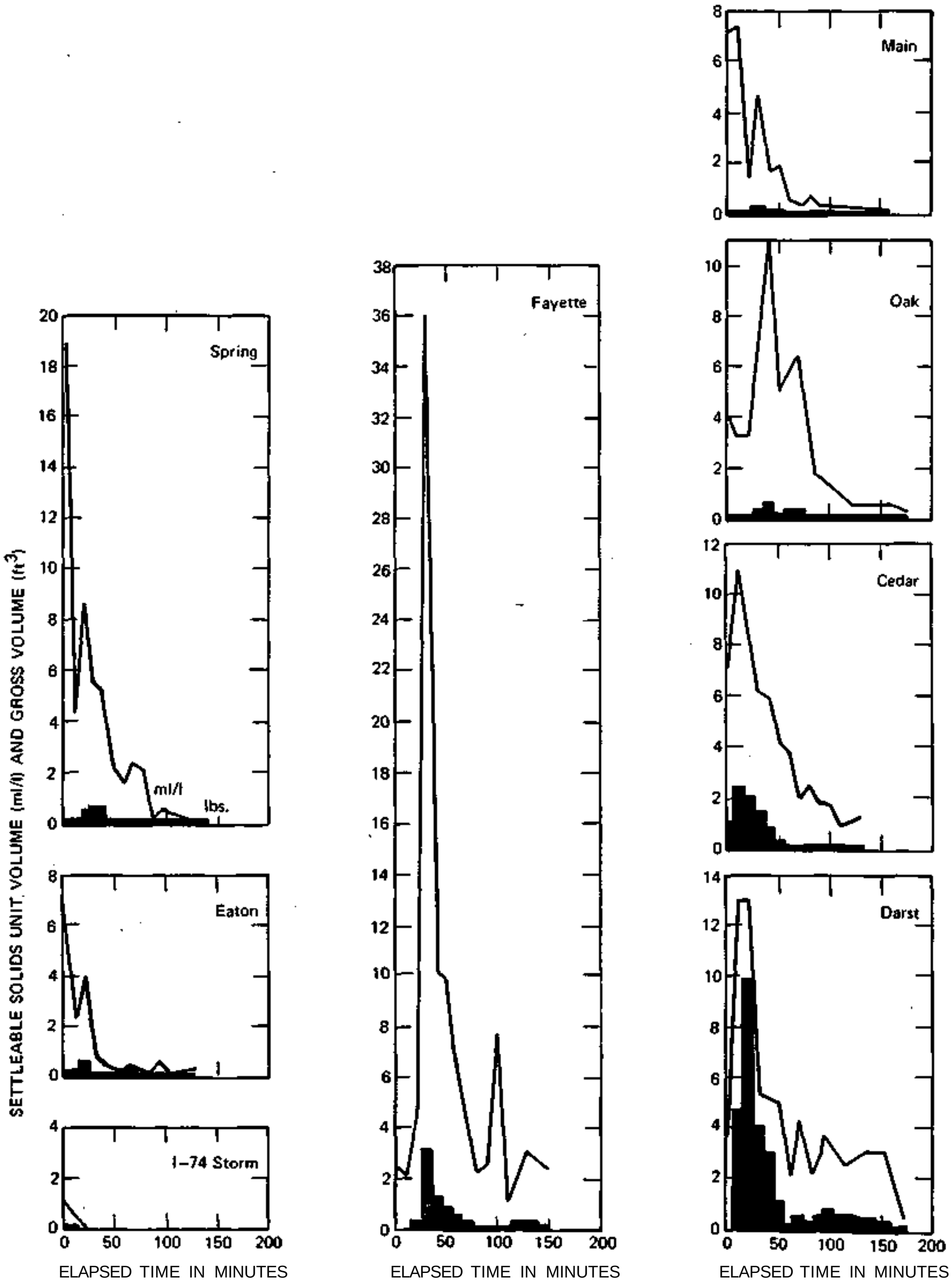


Figure 15. Settleable solids unit volume and gross volume, September 17, 1982

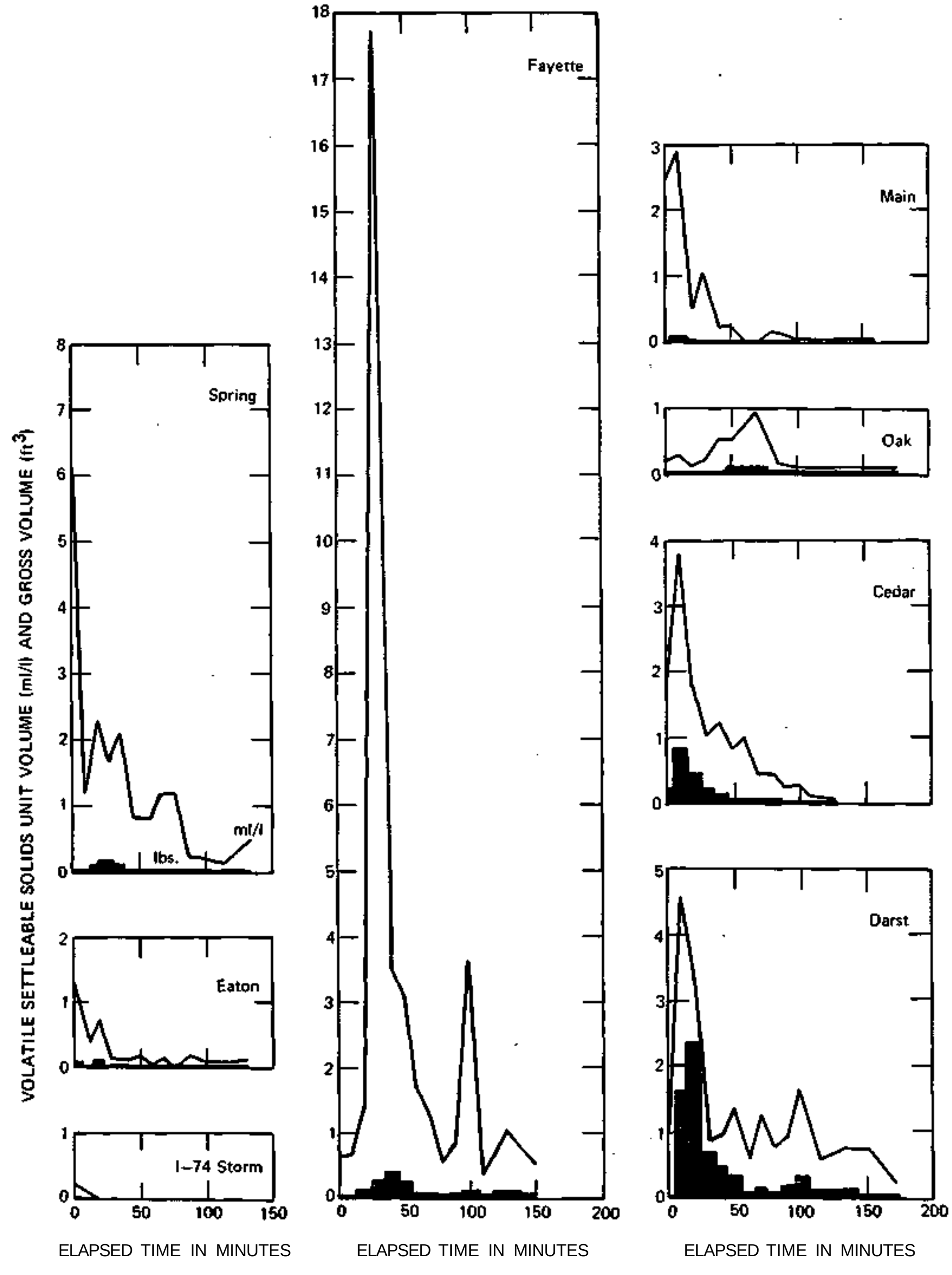


Figure 16. Volatile settleable solids unit volume and gross volume, September 17, 1982

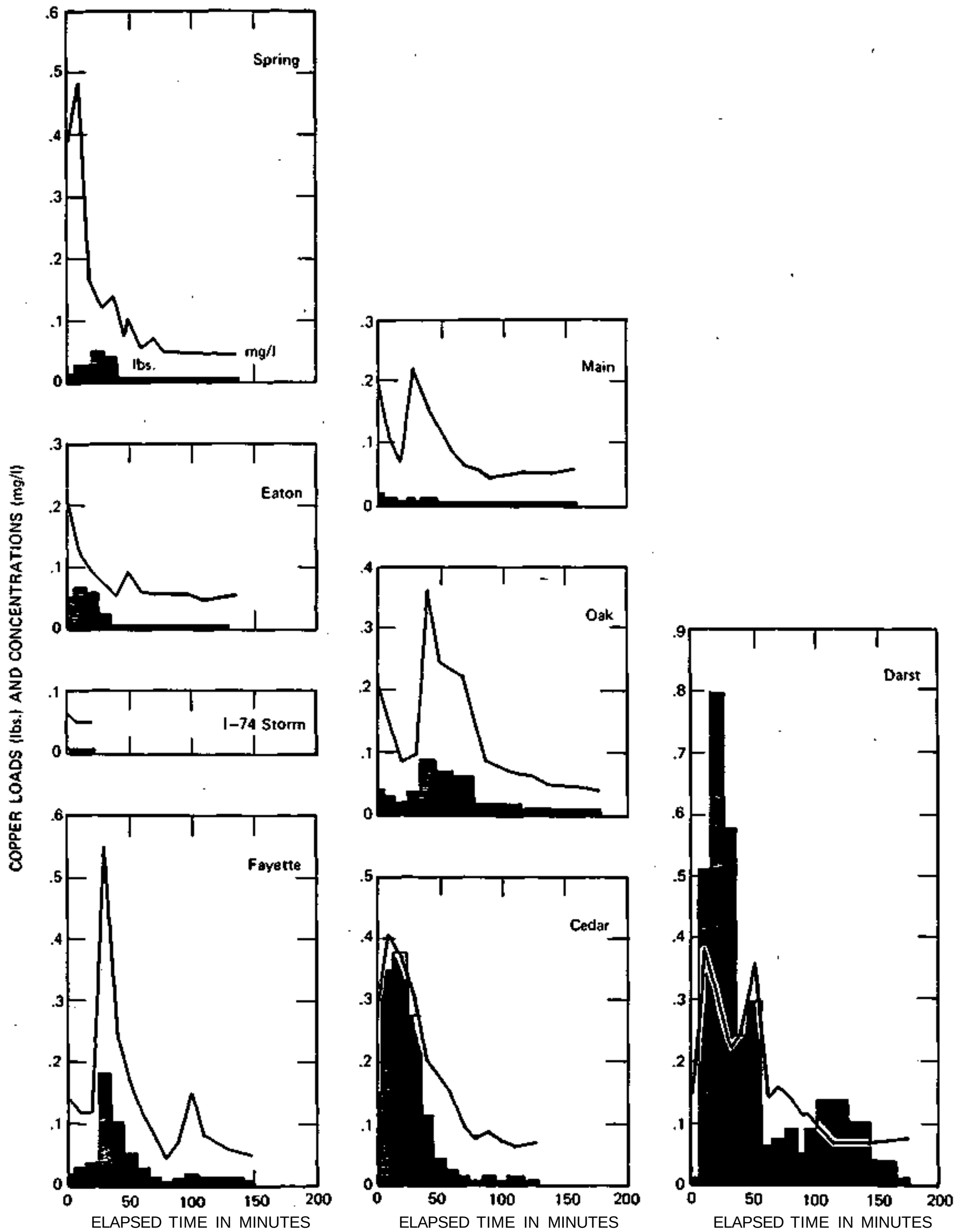


Figure 17. Copper loads and concentrations, September 17, 1982

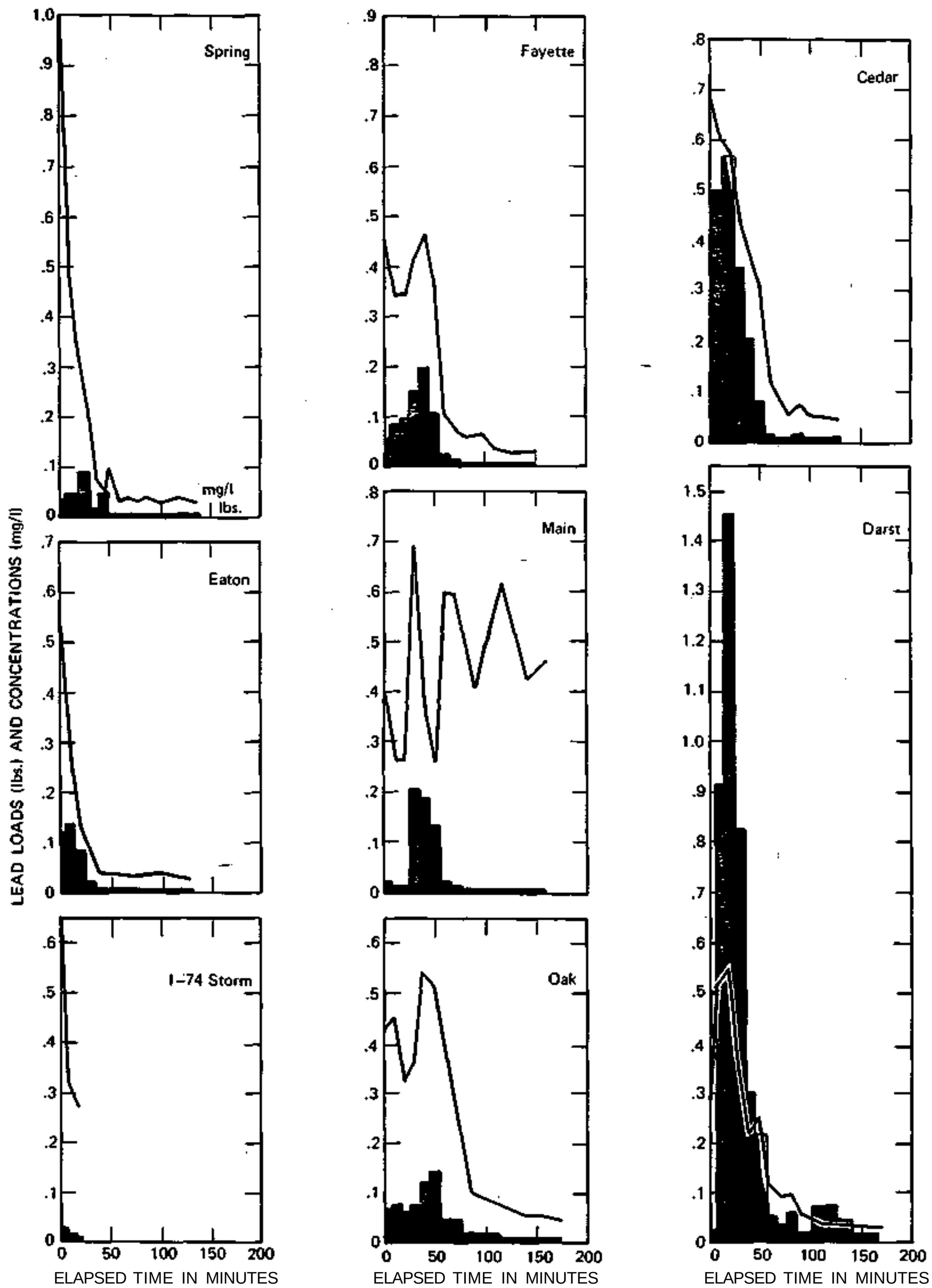


Figure 18. Lead loads and concentrations, September 17, 1982

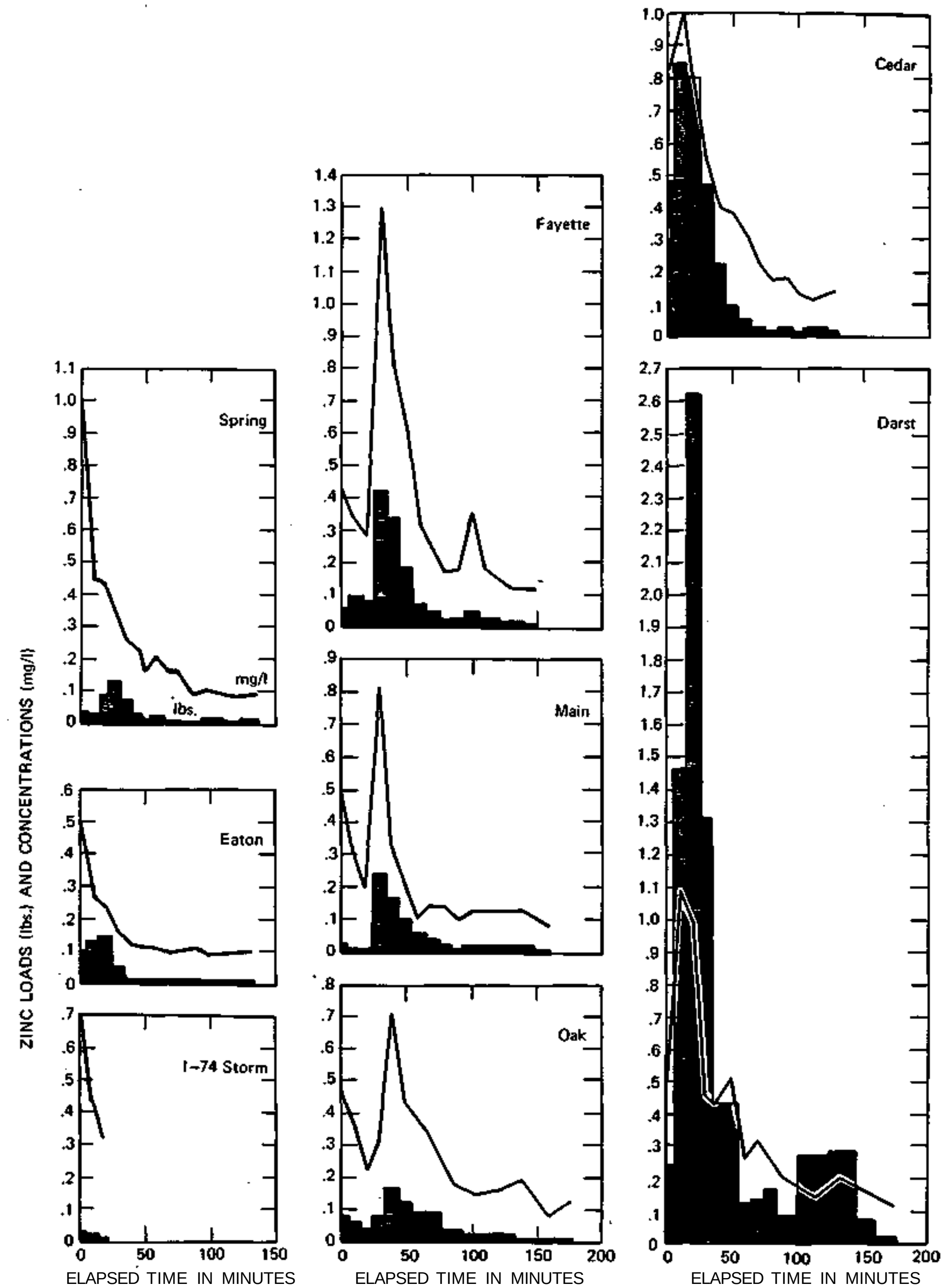


Figure 19. Zinc loads and concentrations, September 17, 1982

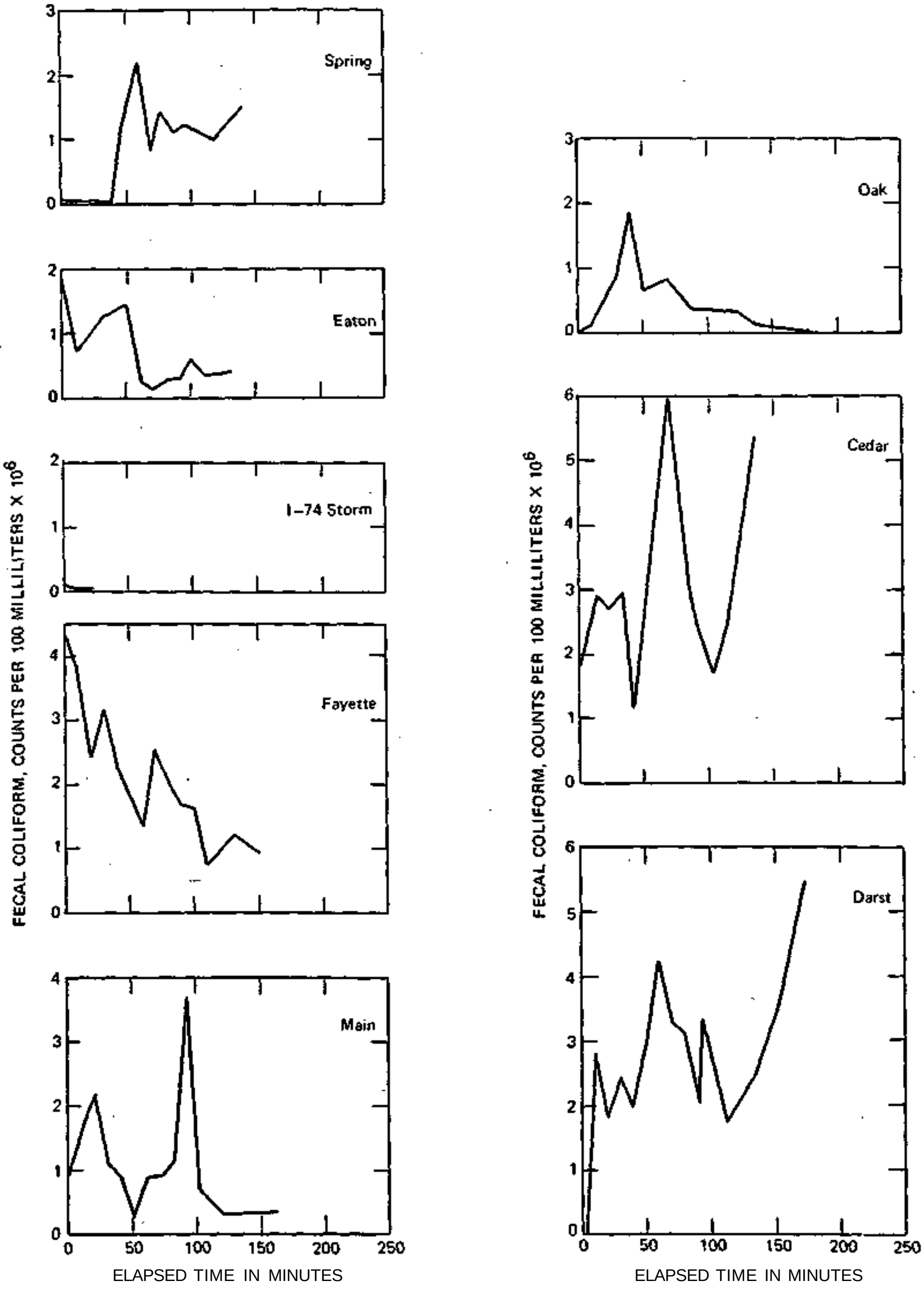


Figure 20. Fecal coliform count, September 17, 1982

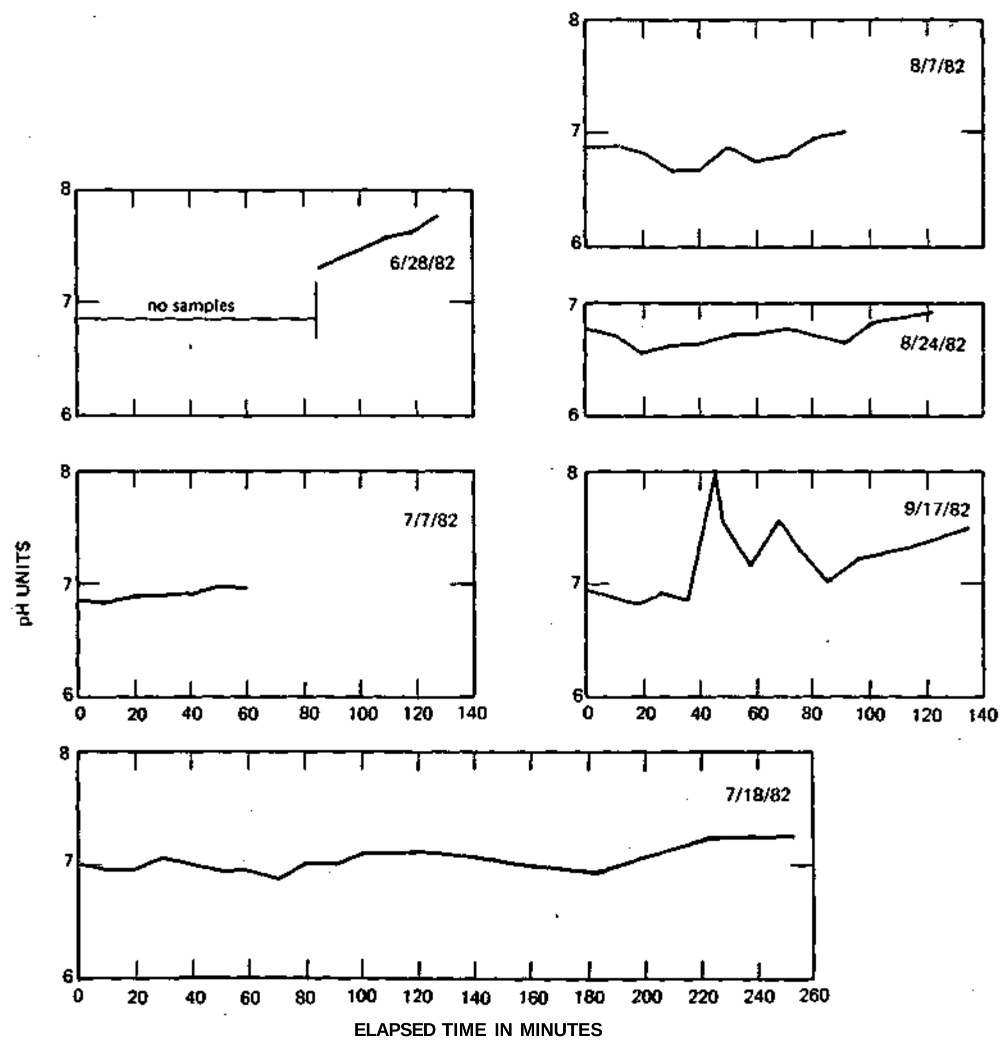


Figure 21. pH values at Spring Street by date

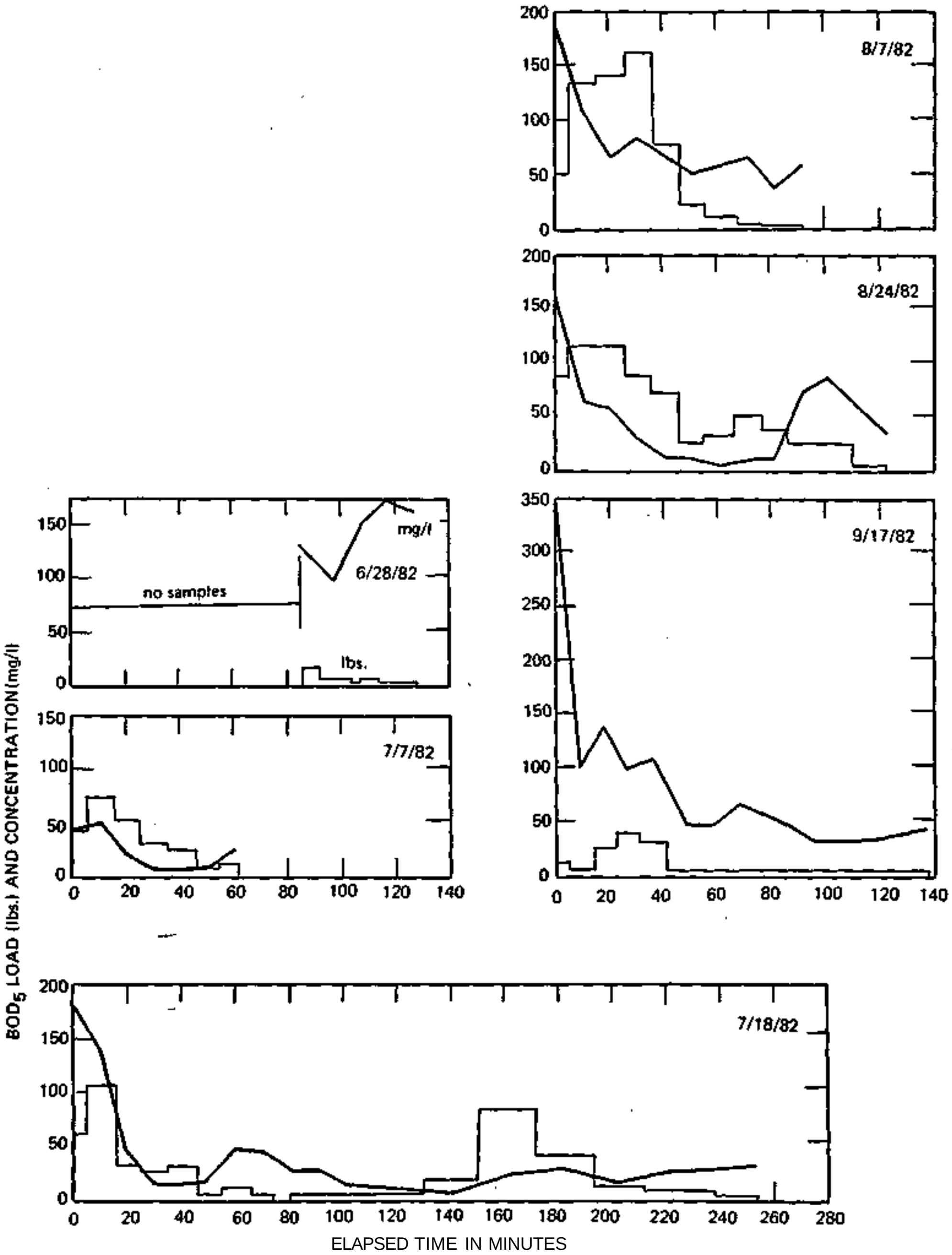


Figure 22. 5-day BOD loads and concentrations at Spring Street by date

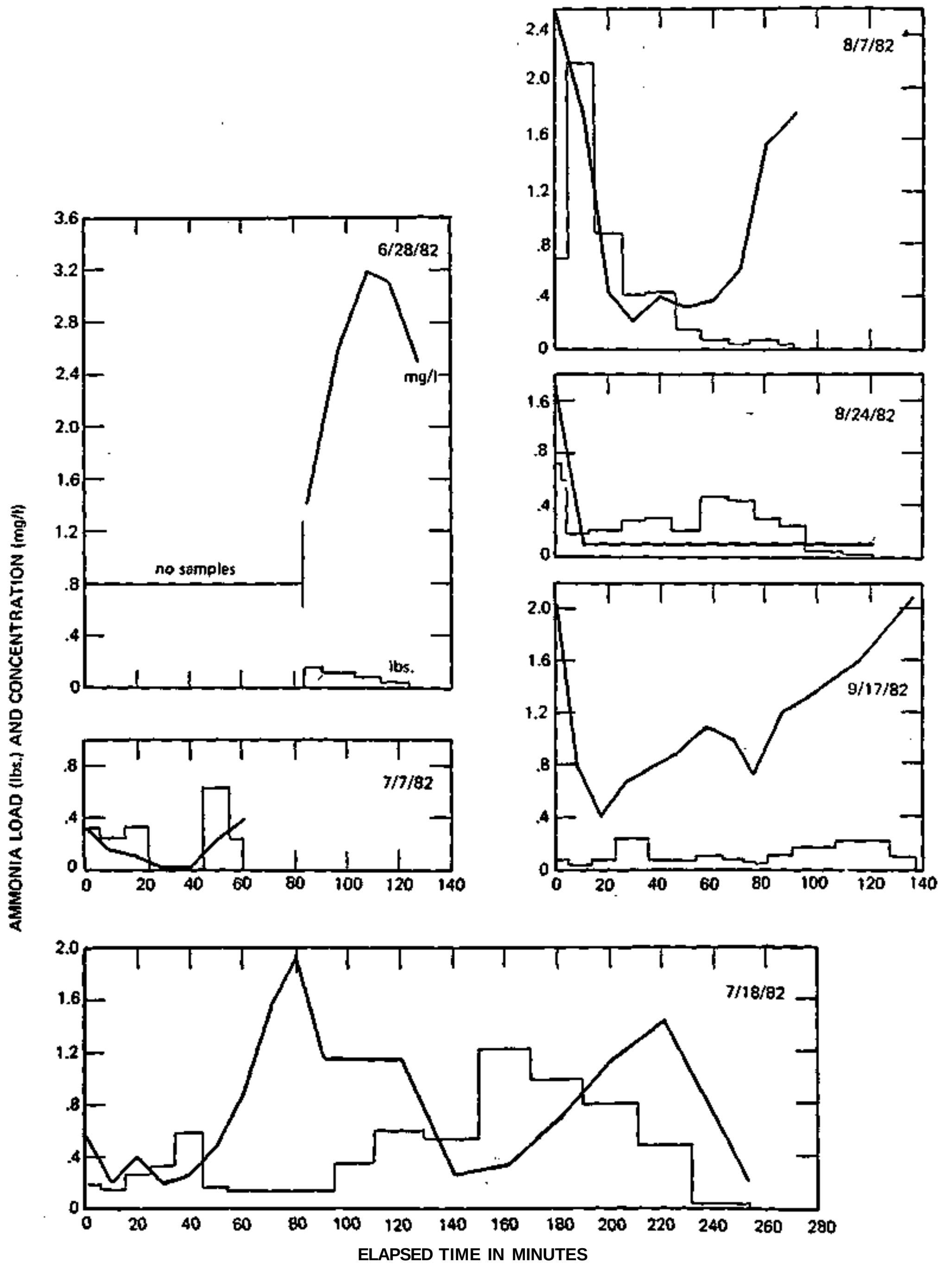


Figure 23. Ammonia loads and concentrations at Spring Street by date

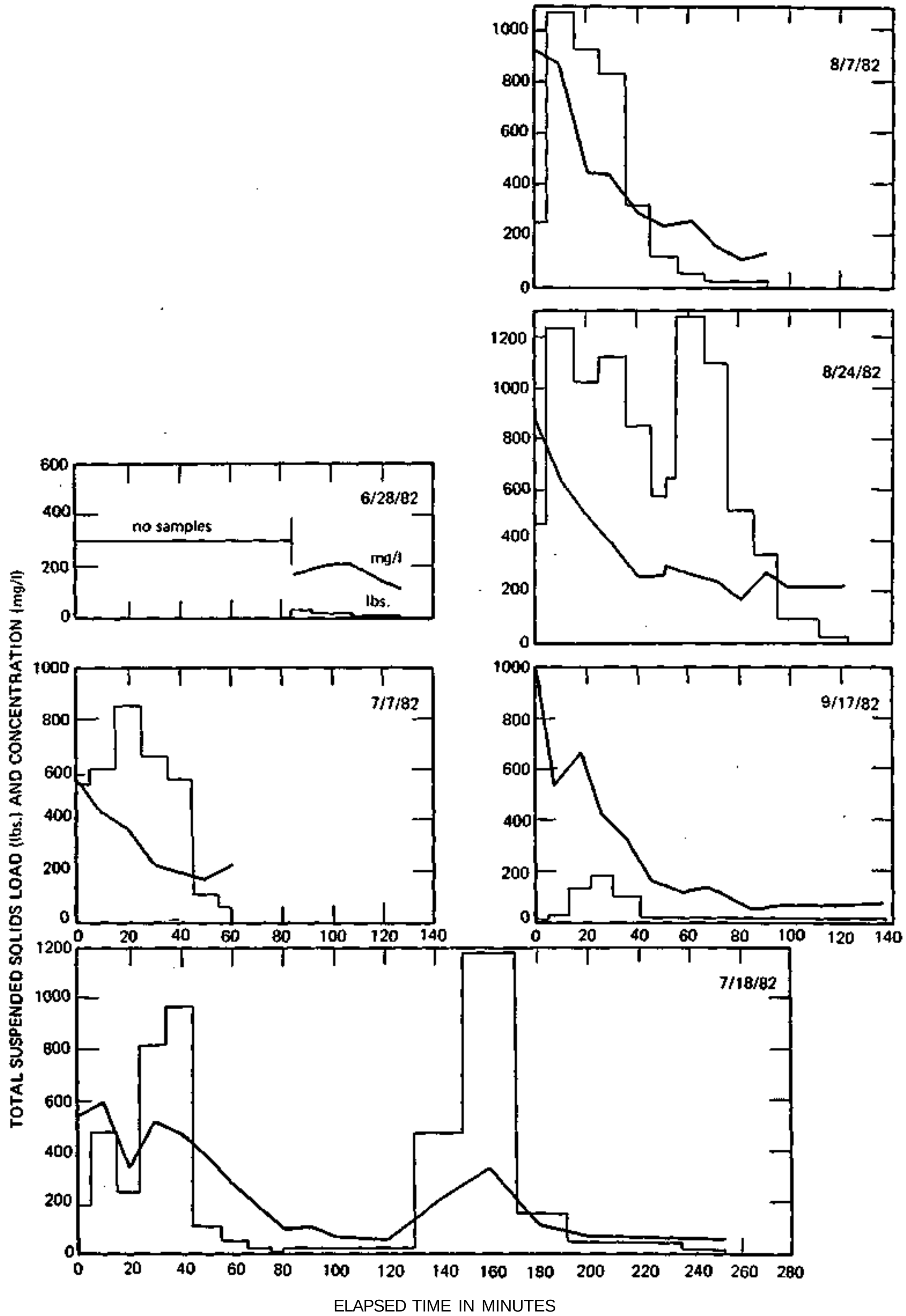


Figure 24. Total suspended solids loads and concentrations at Spring Street by date

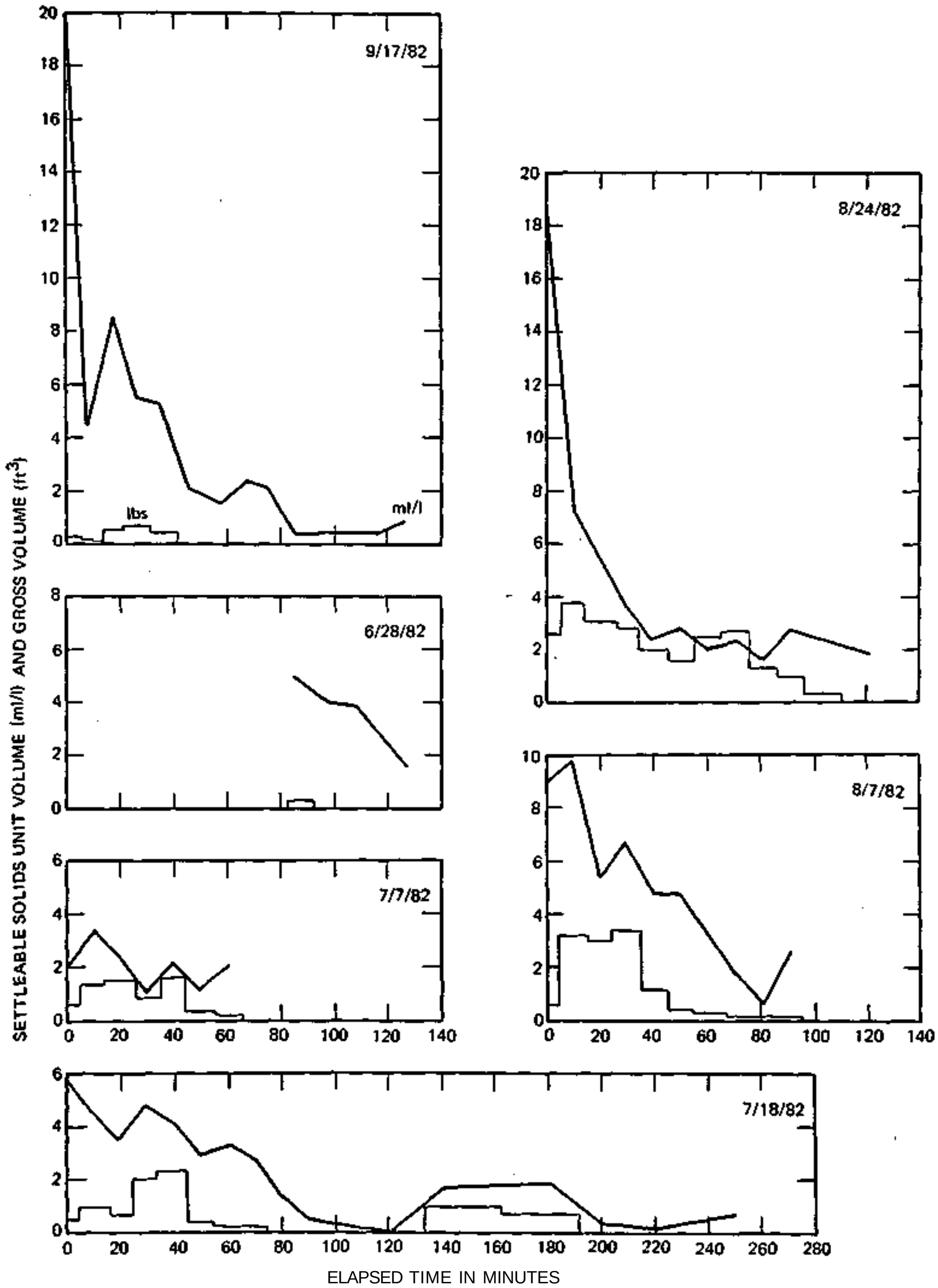


Figure 25. Settleable solids unit volume and gross volume at Spring Street by date

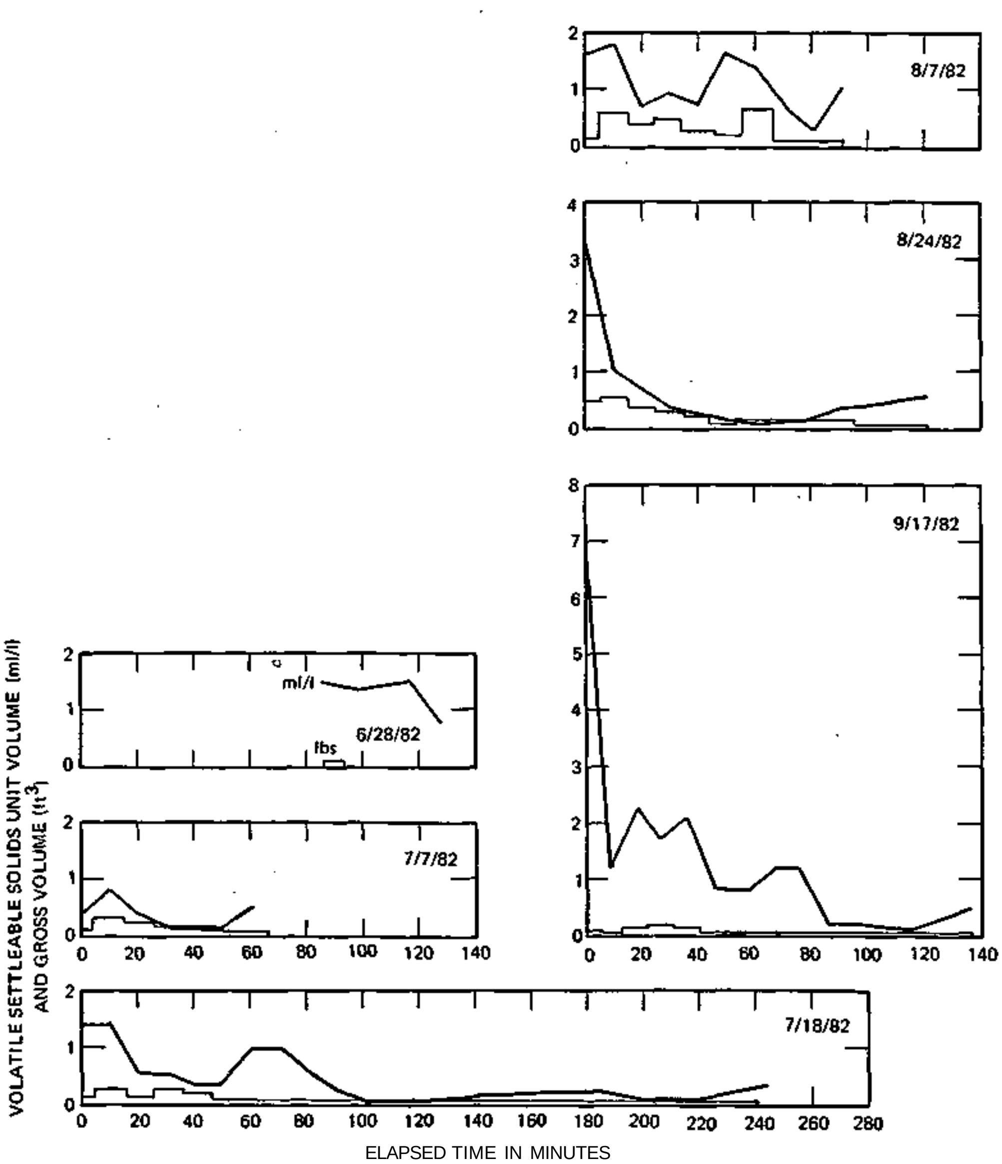


Figure 26. Volatile settleable solids unit volume and gross volume at Spring Street by date

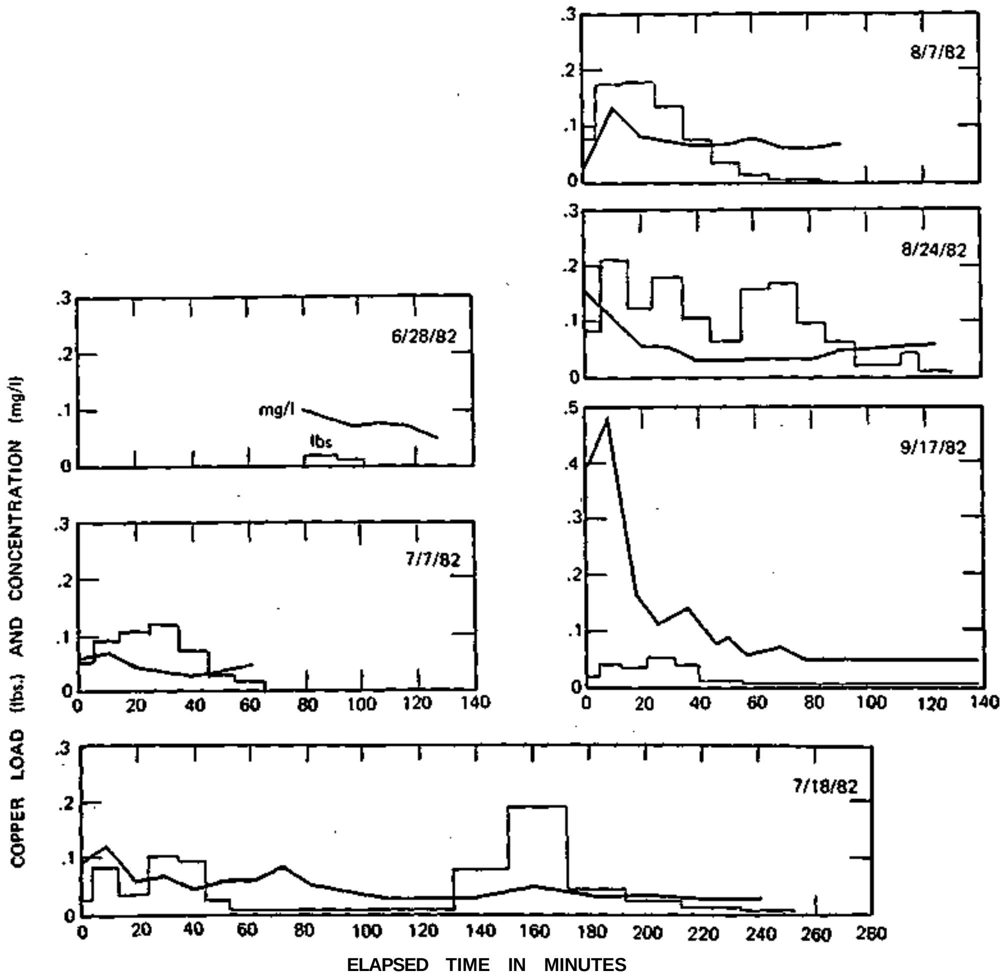


Figure 27. Copper loads and concentrations at Spring Street by date

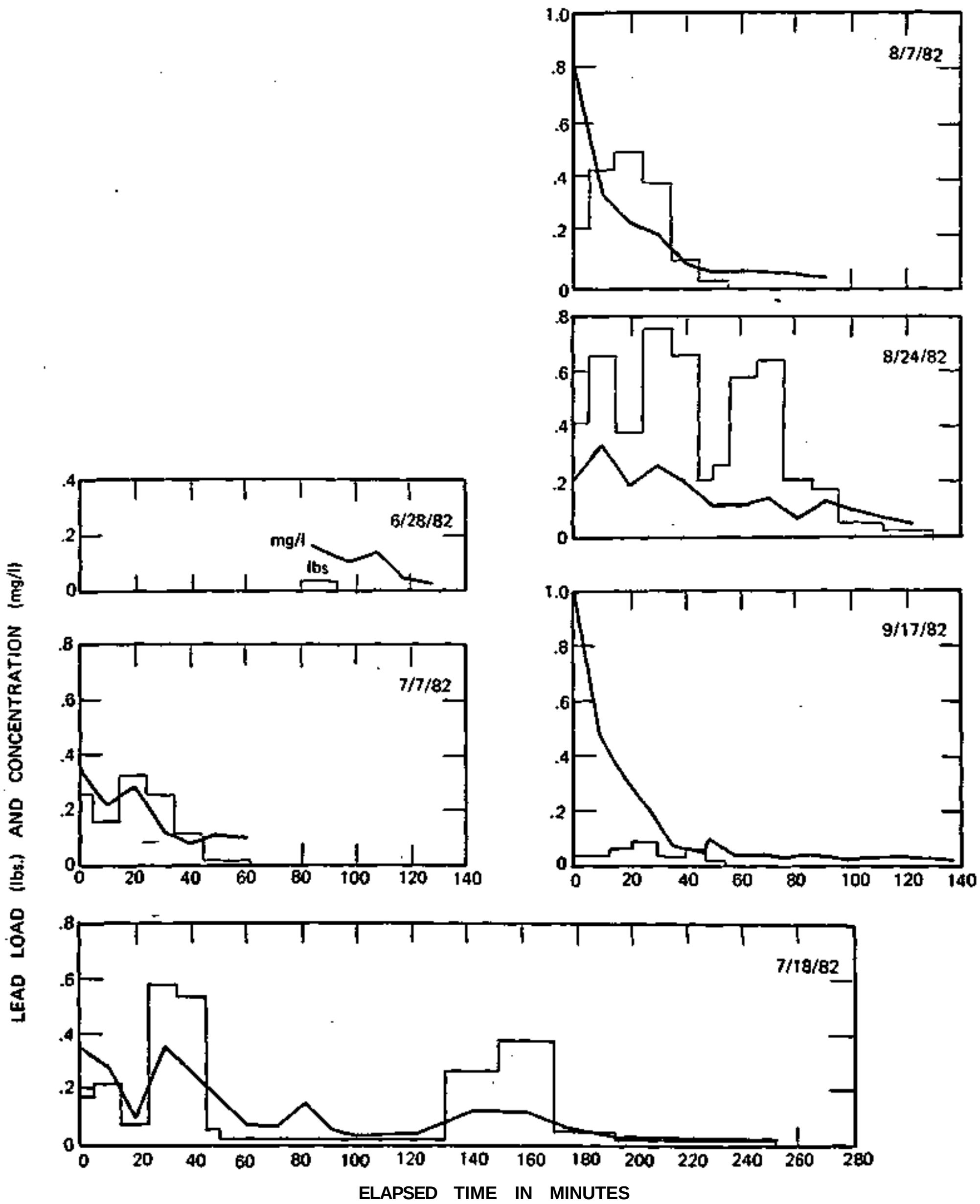


Figure 28. Lead loads and concentrations at Spring Street by date

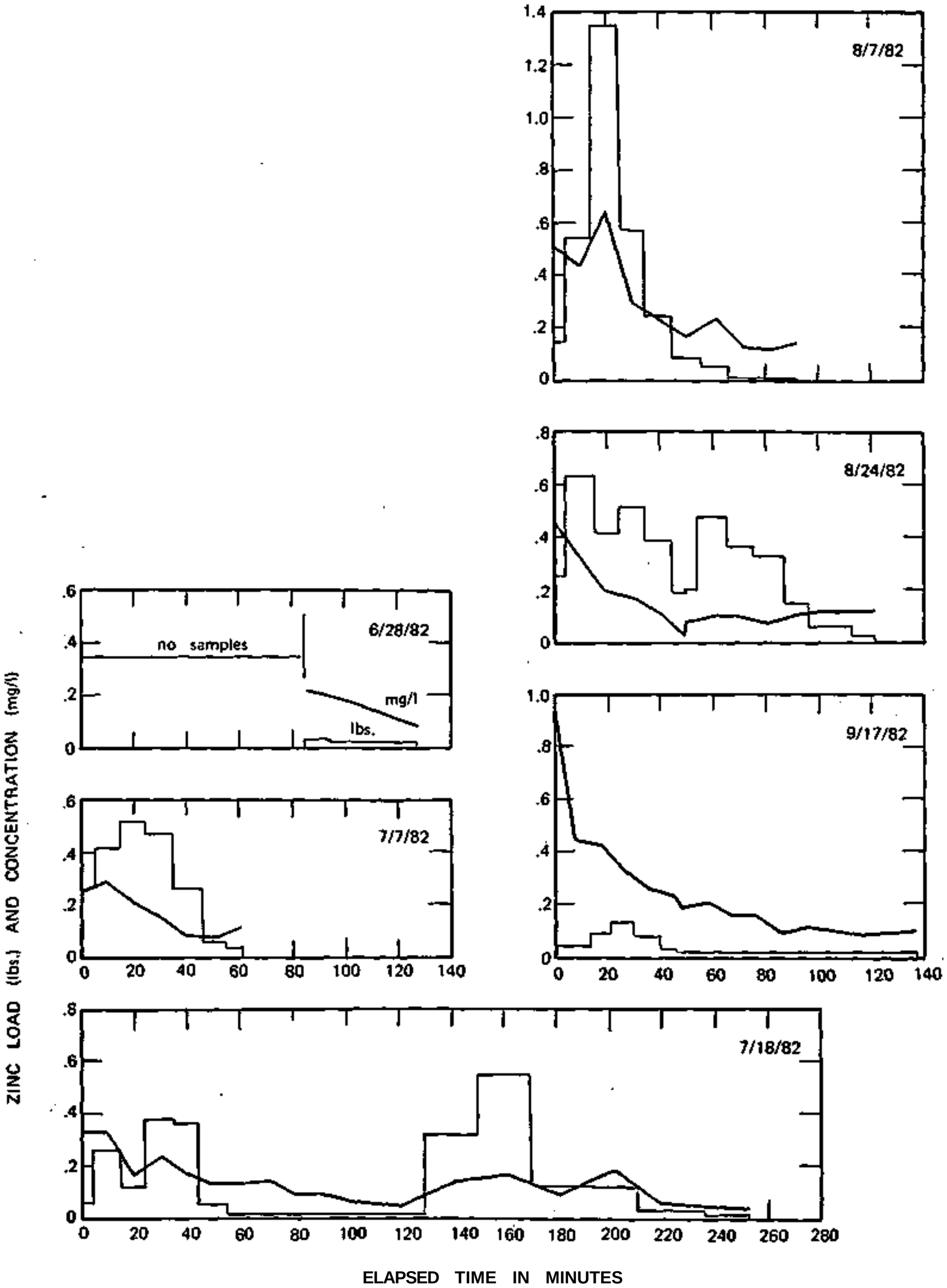


Figure 29. Zinc loads and concentrations at Spring Street by date

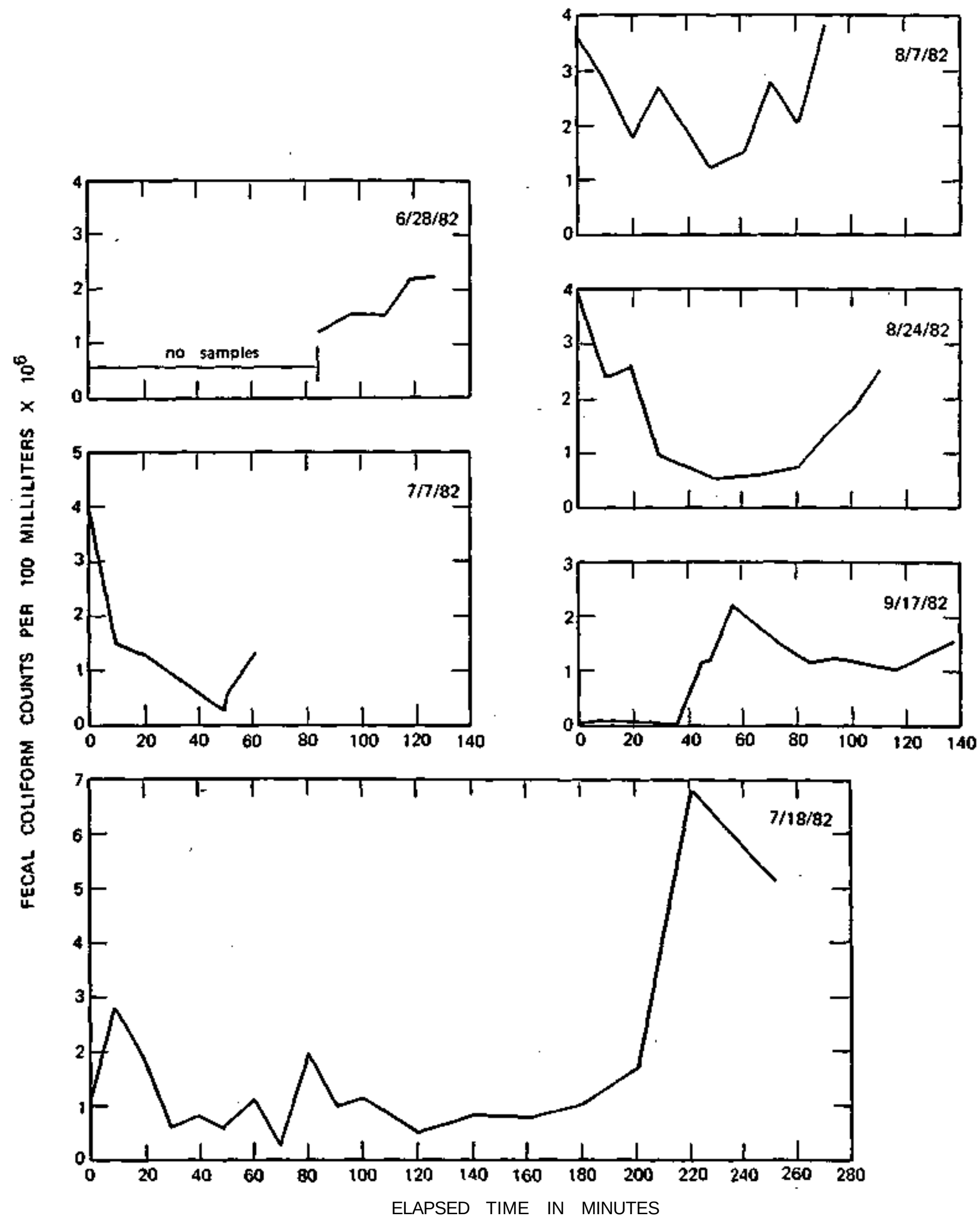


Figure 30. Fecal coliform counts at Spring Street by date

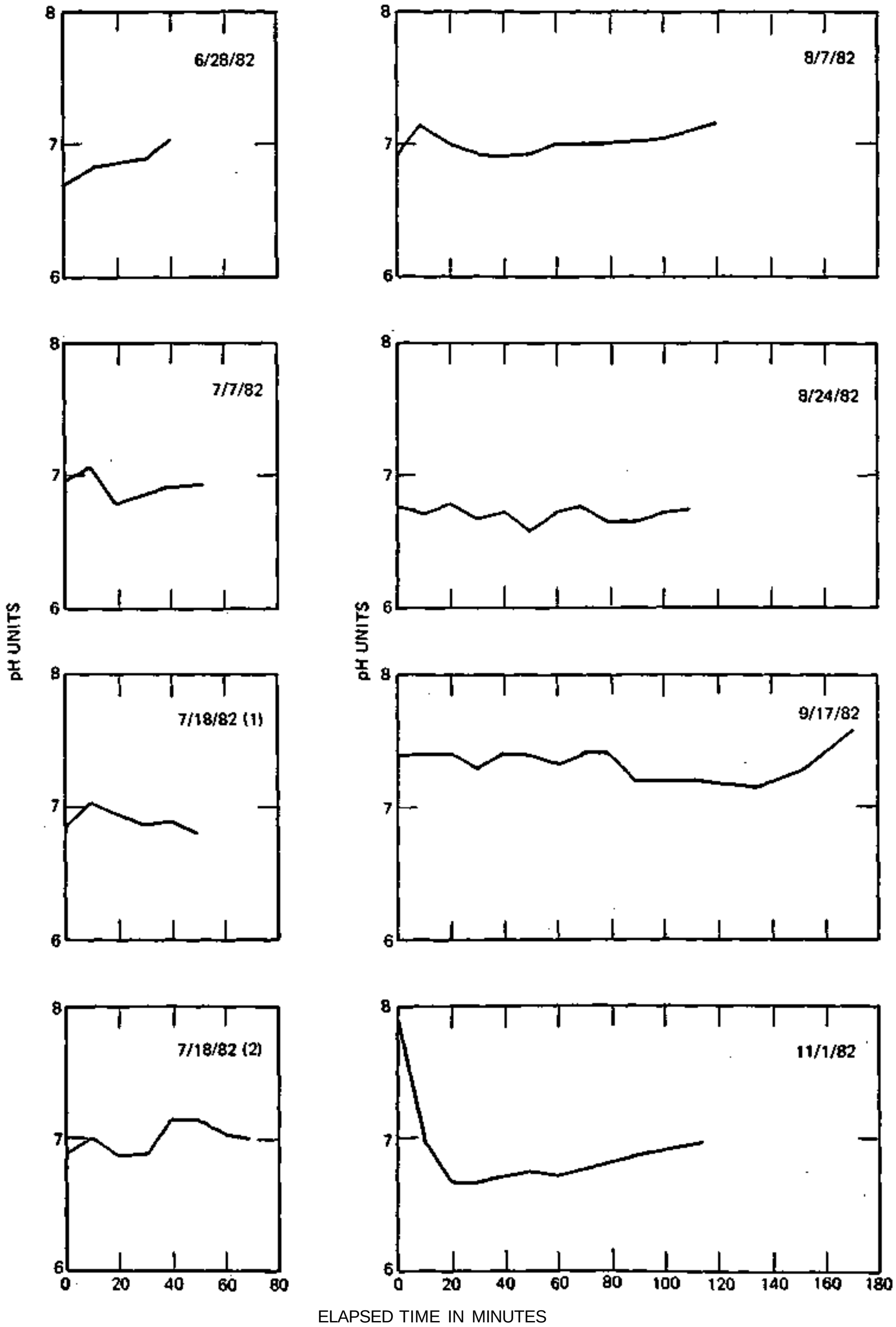


Figure 31. pH values at Darst Street by date

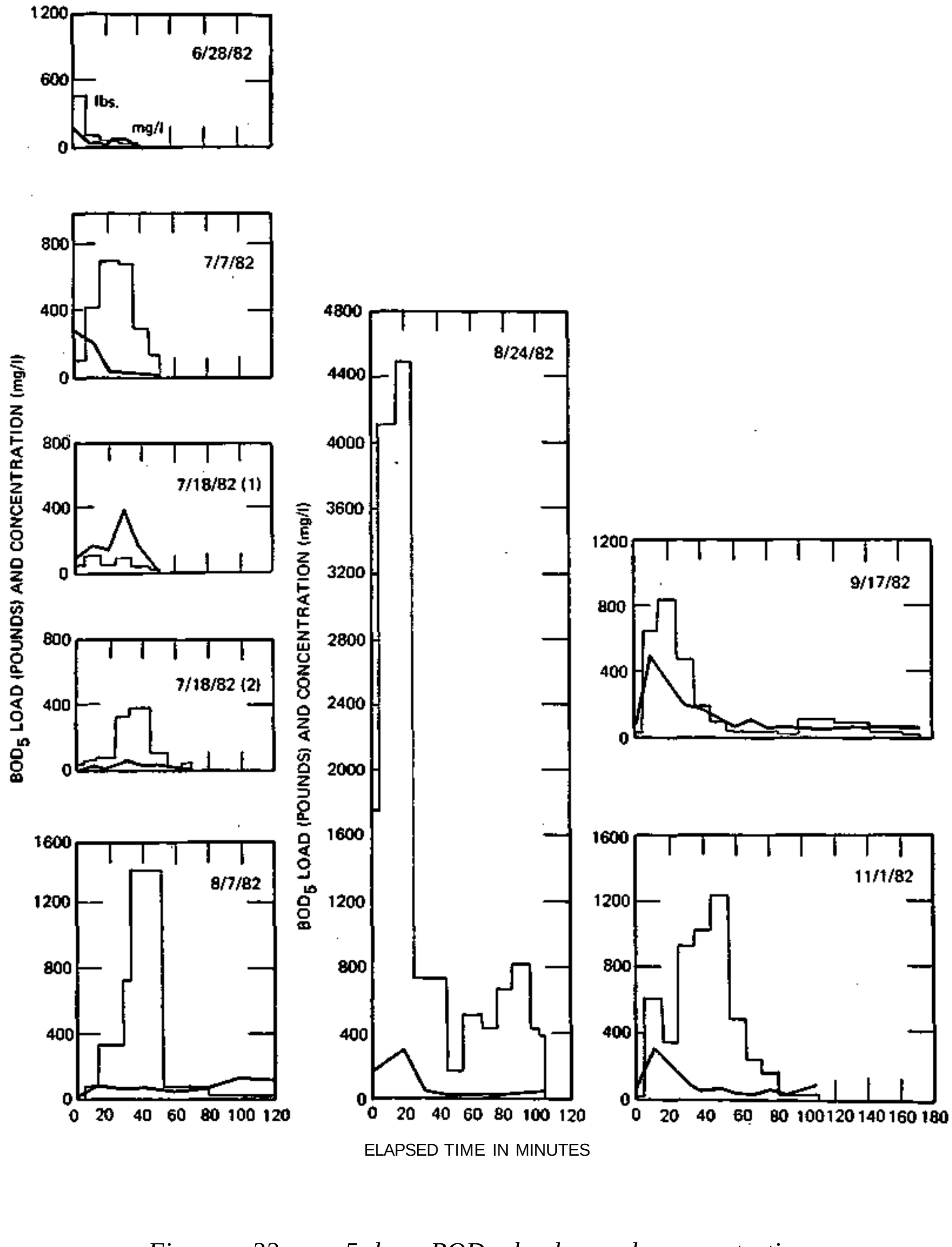


Figure 32. 5-day BOD loads and concentrations at Darst Street by date.

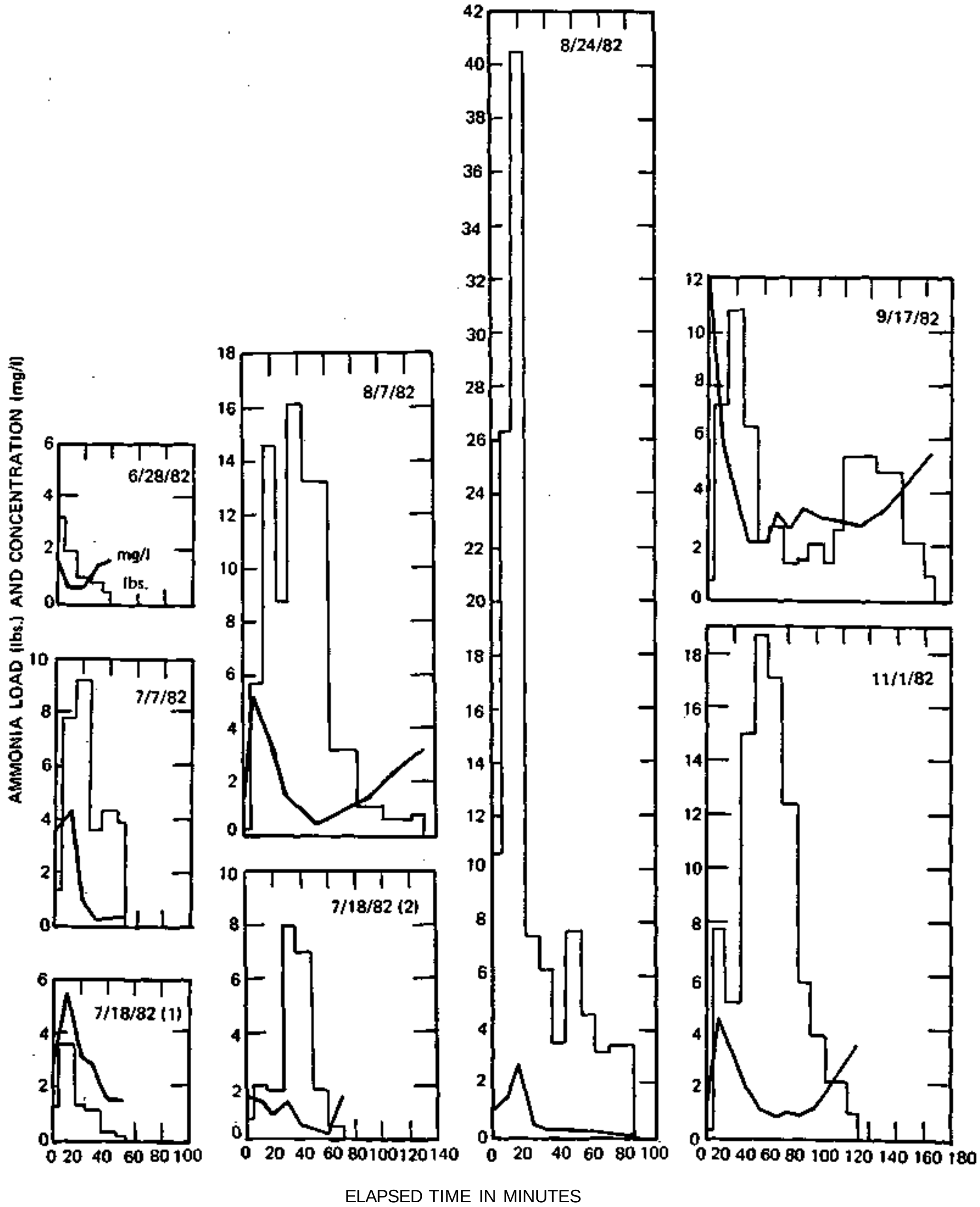


Figure 33. Ammonia loads and concentrations at Darst Street by date

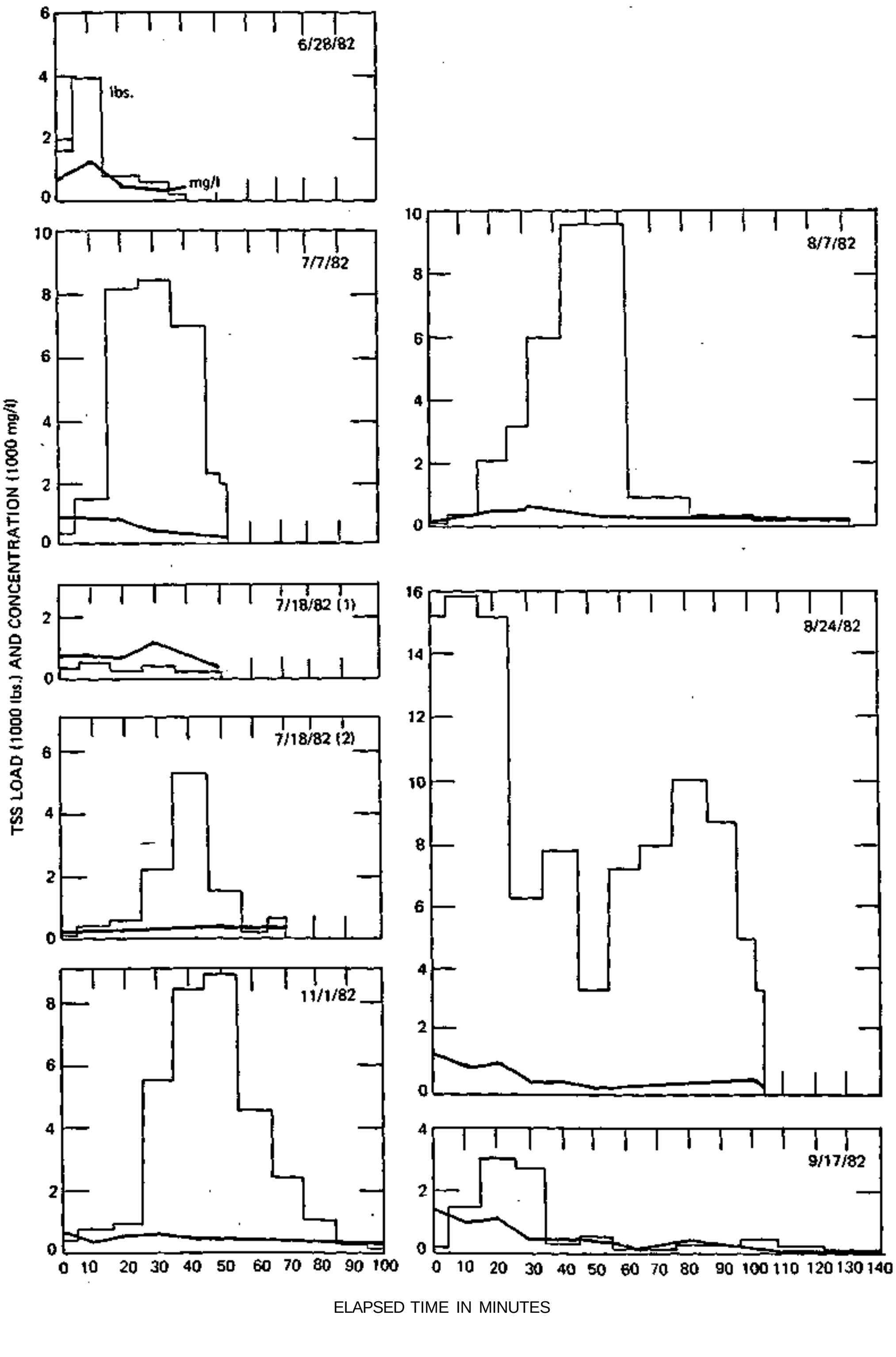


Figure 34. Total suspended solids loads and concentrations at Darst Street by date

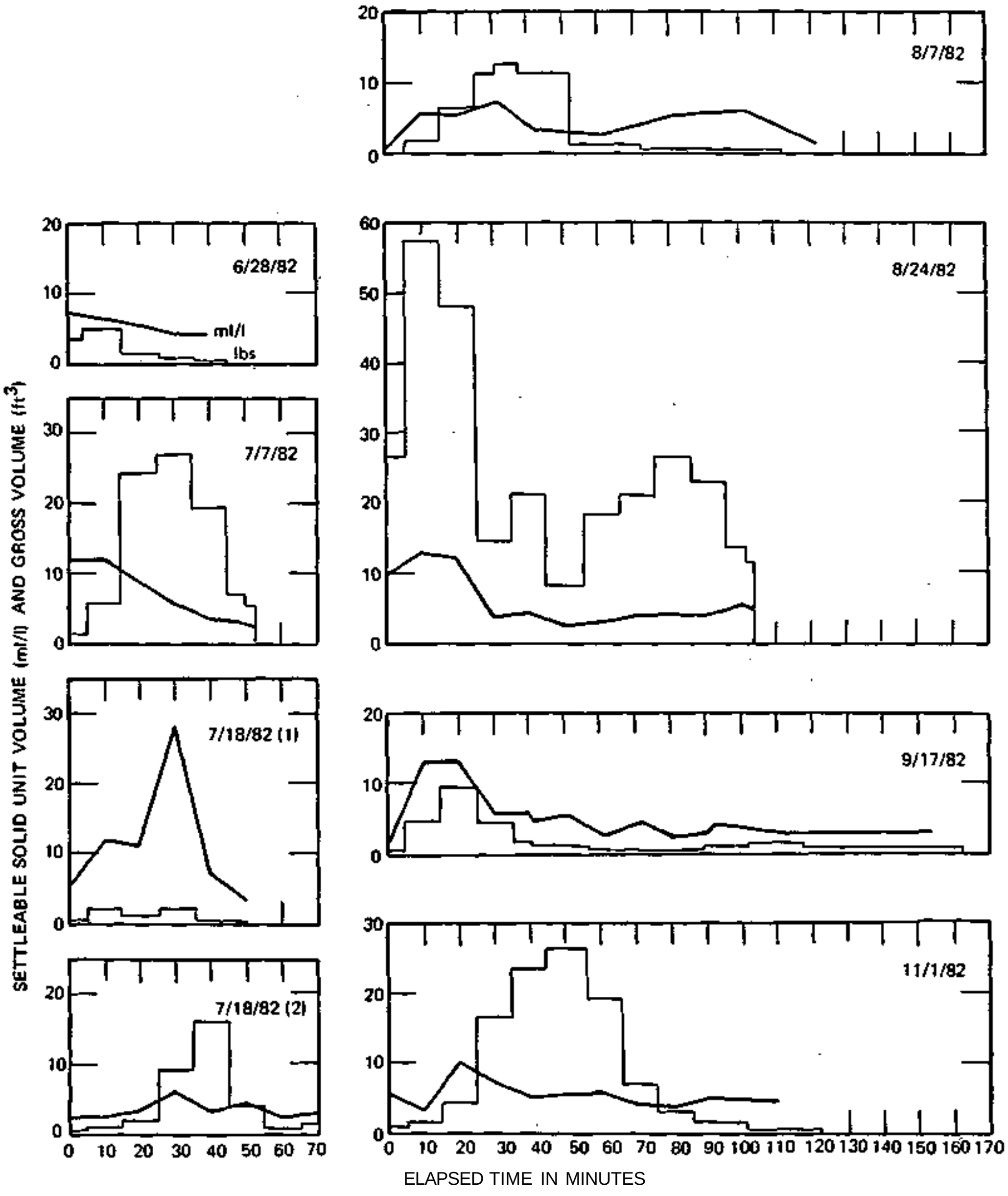


Figure 35. Settleable solids unit volume and gross volume at Darst Street by date

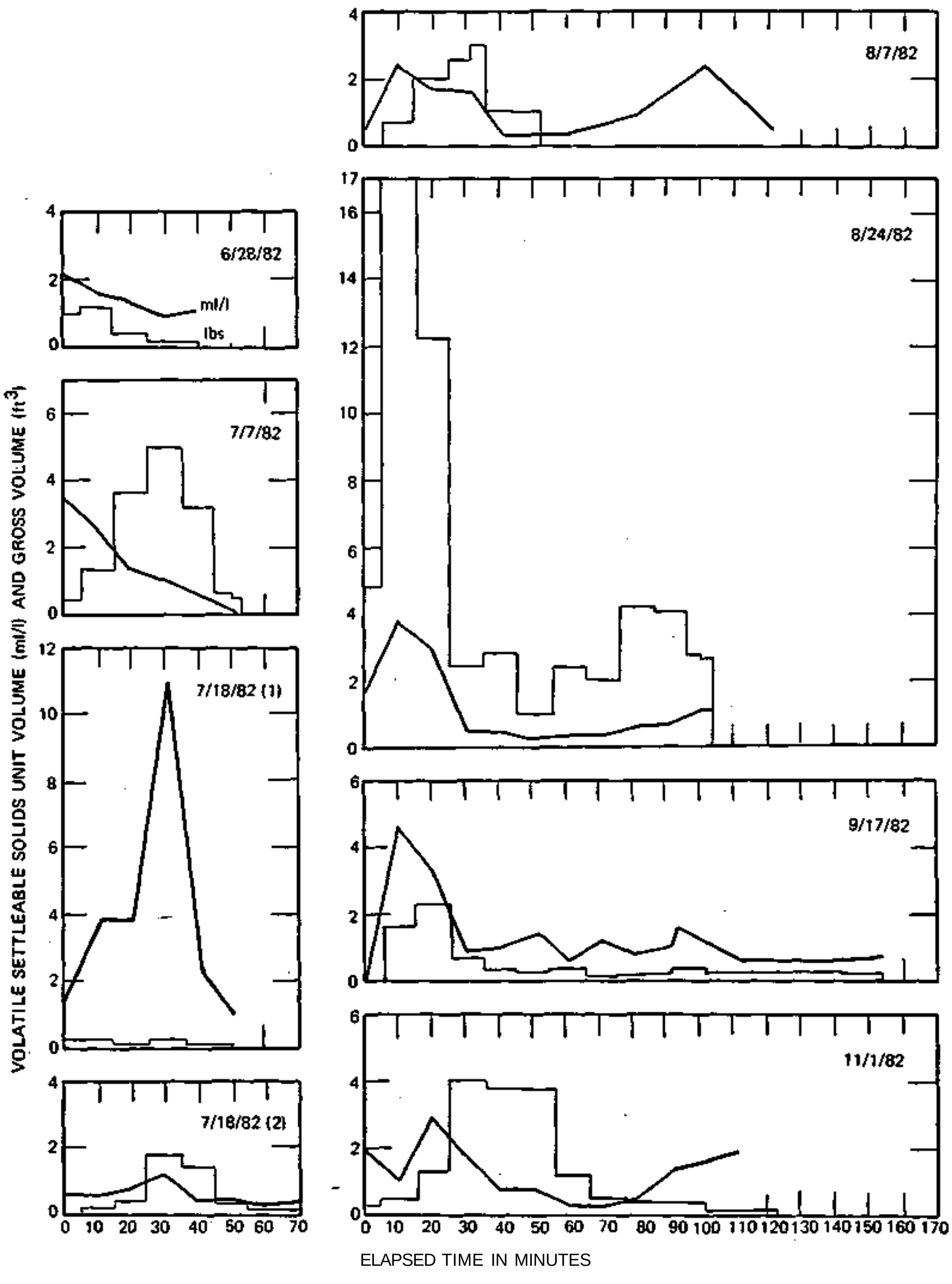


Figure 36. Volatile settleable solids unit volume and gross volume at Darst Street by date

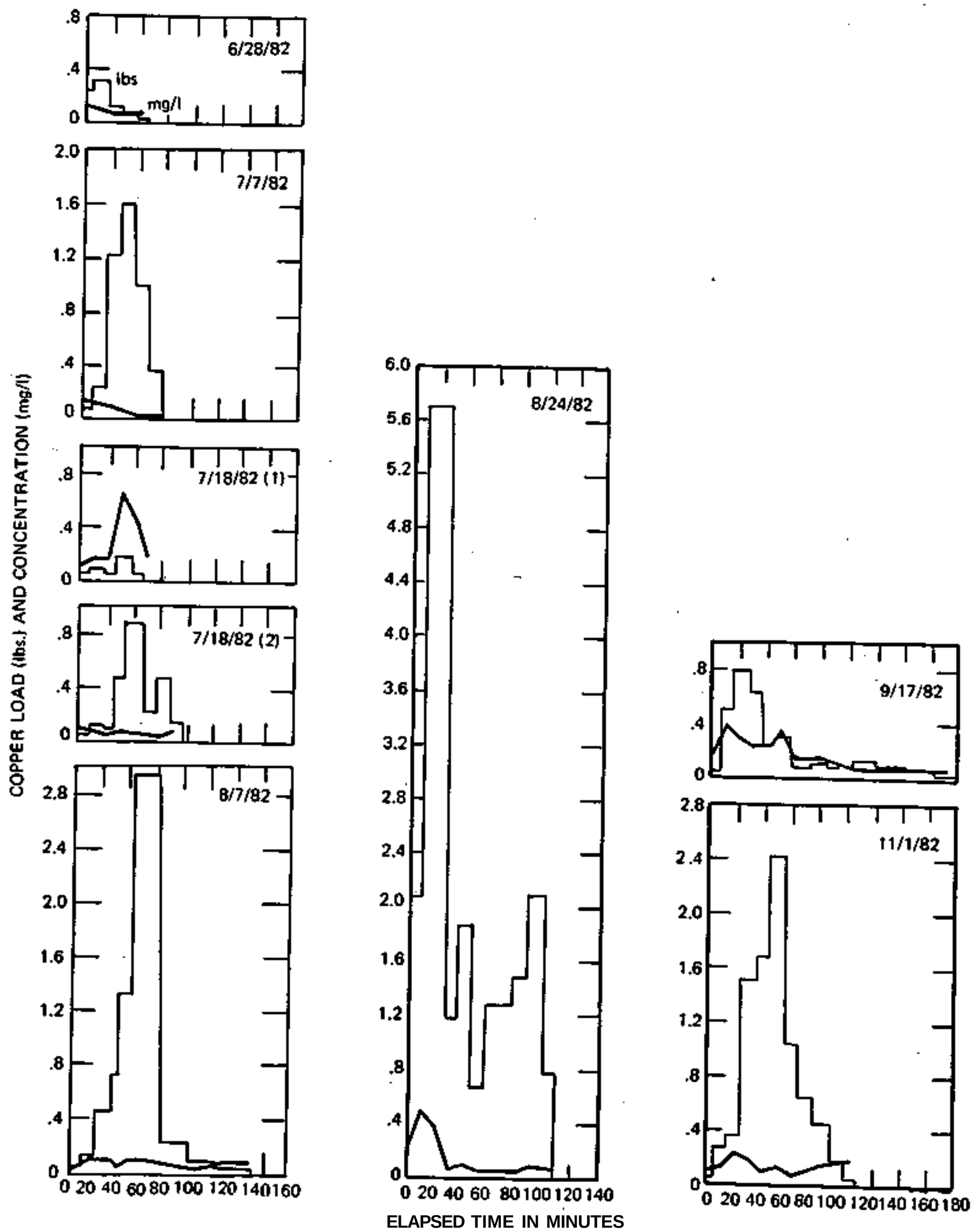


Figure 37. Copper loads and concentrations at Darst Street by date

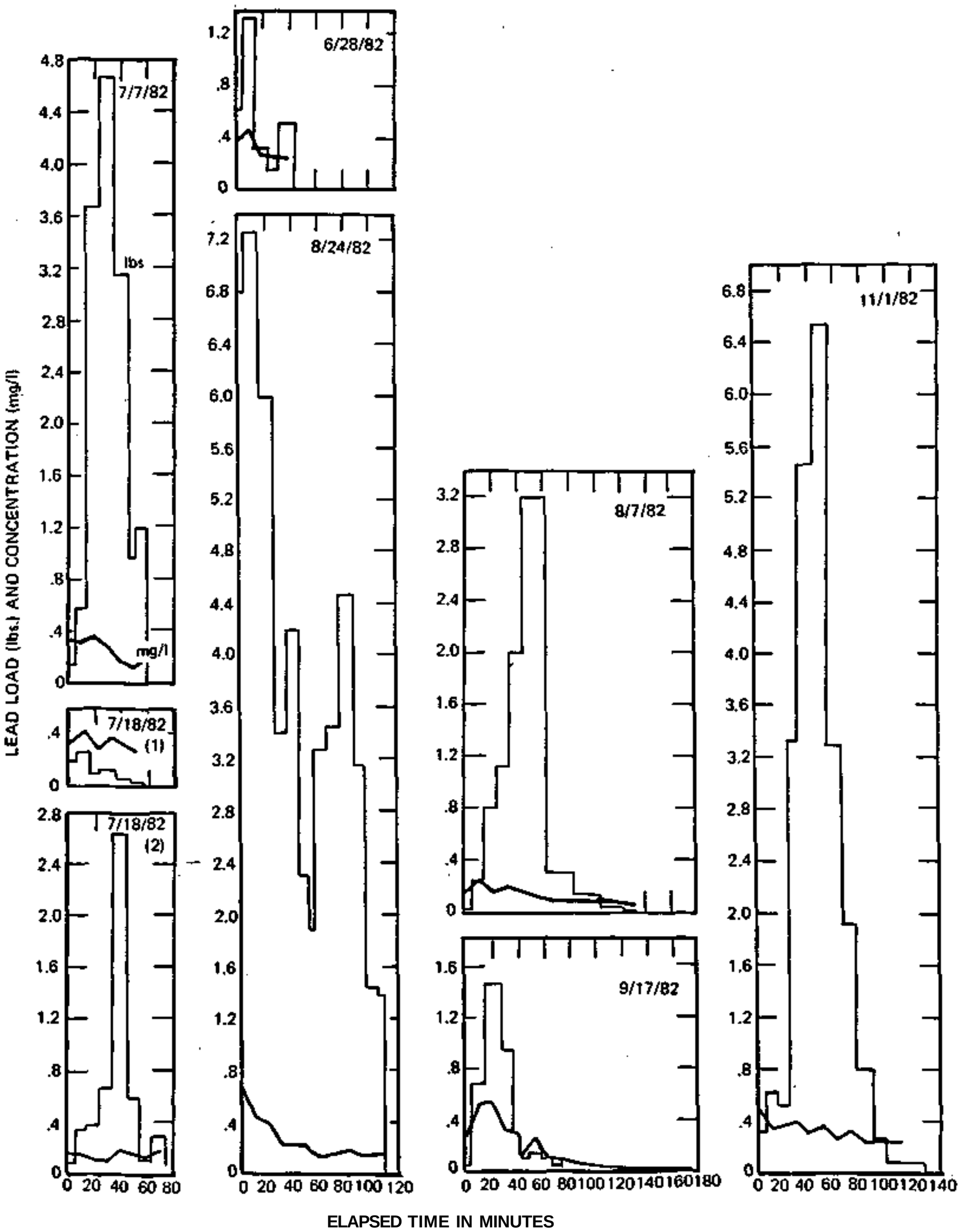


Figure 38. Lead loads and concentrations at Darst Street by date

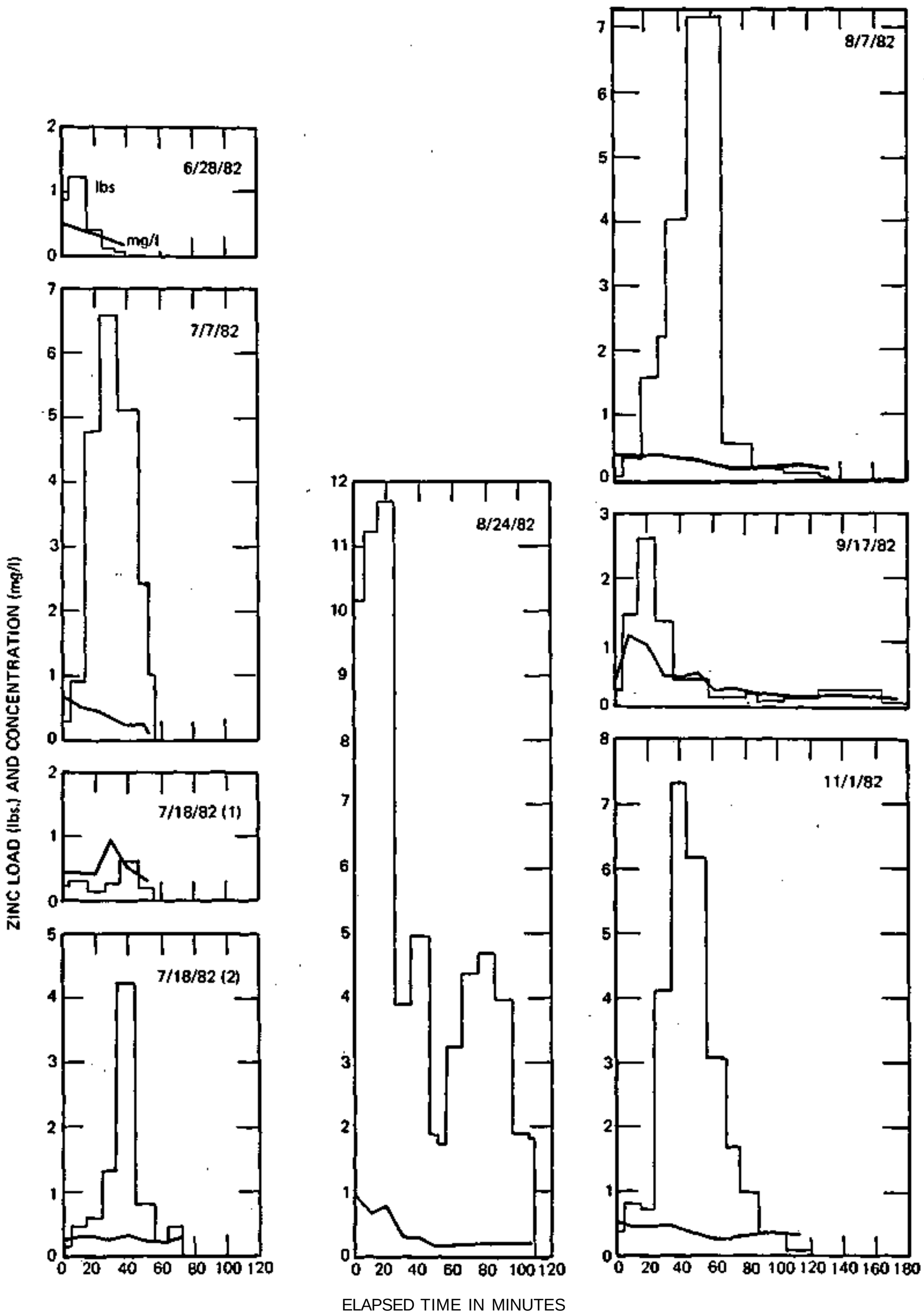


Figure 39. Zinc loads and concentrations at Darst Street by date

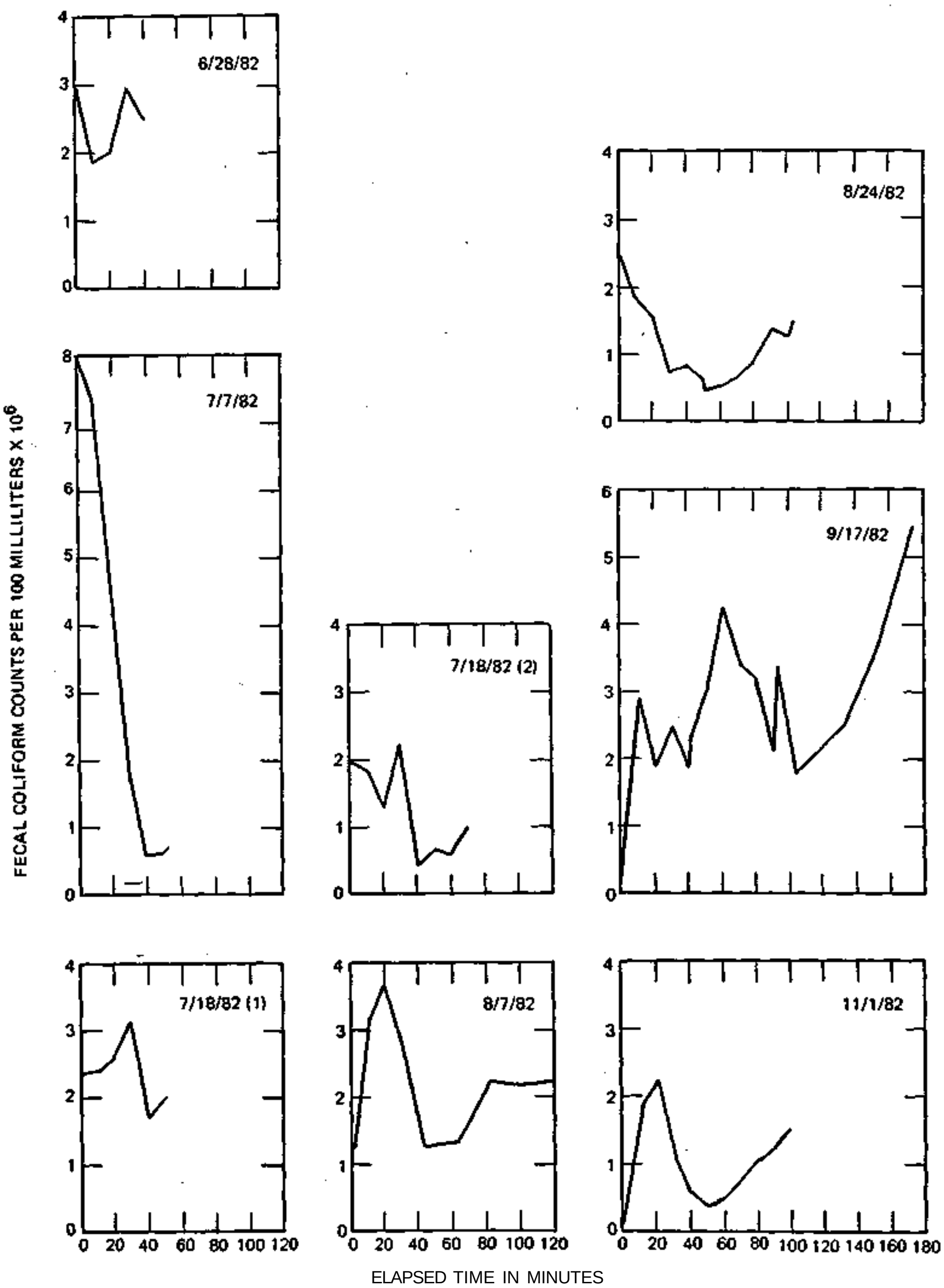


Figure 40. Fecal coliform counts at Darst Street by date

Table 41. Estimated Loads from Monitored Sewers

Parameter	Sewer	Sampling Dates 6/28	7/7	7/18	8/7	8/24	9/17	11/1
BOD_5 (lbs)	Spring	269	242	474	610	781	166	--
	Eaton	160	104	181	158	130	144	--
	Fayette	407	169	414	835	913	503	--
	Main	40	54	94	111	254	92	--
	Oak	82	343	118	153	872	158	--
	Cedar	2840	884	1354	1329	4882	900	--
	South	234	119	161	179	1005	283	398
	Darst	720	2492	1332	3168	15508	2912	5084
	Total	4752	4437	4218	6543	24345	5158	--
Ammonia (lbs)	Spring	5.46	2.51	7.63	5.06	3.62	1.52	--
	Eaton	2.83	2.13	2.70	2.48	3.53	1.22	--
	Fayette	1.33	1.65	2.56	10.9	12.09	7.47	--
	Main	0.23	0.00	0.82	1.03	2.53	2.58	--
	Oak	3.45	2.69	1.67	2.62	3.11	3.57	--
	Cedar	29.13	11.26	31.52	13.49	39.l6	10.46	--
	South	1.61	0.38	1.78	1.83	3.78	2.09	5.35
	Darst	7.38	31.74	30.30	63.99	124.40	54.40	89.0
	Total	57.42	52.36	78.98	101.40	191.22	83.31	--
Total Suspended . Solids (lbs)	Spring	1230	3509	4926	3579	9291	593	--
	Eaton	5003	2544	3826	2656	3855	524	--
	Fayette	1641	1637	1847	3158	6221	1511	--
	Main	401	774	1133	942	3615	488	--
	Oak	3868	4920	6417	3959	9424	820	--
	Cedar	26098	10474	14510	11902	34353	2767	--
	South	4200	1901	3185	2632	8955	965	3990
	Darst	6613	29529	12724	22247	109119	8542	33447
	Total	49054	55288	58568	51095	184833	16210	--
Cadmium (lbs)	Spring							
	Eaton							
	Fayette							
	Main	Conc. Below- Detectable Limits						
	Oak							
	Cedar							
	South							
	Darst							
	Total							
Copper (lbs)	Spring	0.45	0.48	0.84	0.70	1.31	0.23	--
	Eaton	0.71	0.34	0.66	0.56	0.79	0.22	--
	Fayette	0.66	0.34	0.46	0.89	1.31	0.53	--
	Main	0.14	0.19	0.39	0.34	1.19	0.31	--
	Oak	0.68	0.52	0.63	0.62	0.43	0.36	--
	Cedar	2.77	1,74	3.30	2.87	8.83	1.38	--
	South	1.45	0.82	1.89	2.23	3.35	1.38	2.61
	Darst	0.70	4.91	2.98	6.09	28.05	3.35	8.78
	Total	7.56	9.34	11.15	14.30	49.76	7.76	--

Concluded on next page

Table 41. Estimated Loads from Monitored Sewers (Concluded)

Parameter	Sewer	6/28	7/7	7/18	8/7	8/24	9/17	11/1
		Sampling Dates						
Lead	Spring	1.19	2.03	2.42	1.68	4.90	0.34	--
(lbs)	Eaton	3.41	1.47	2.63	1.30	2.05	0.38	--
	Fayette	0.89	0.79	0.99	1.07	3.83	0.77	--
	Main	0.62	0.56	2.18	0.94	3.99	0.64	--
	Oak	2.32	1.63	2.80	1.76	0.66	0.70	--
	Cedar	9.50	5.10	6.41	5.70	15.42	2.24	--
	South	4.02	1.77	3.60	3.85	11.18	2.50	7.34
	Darst	2.41	14.37	5,63	7.79	48.98	4.08	23.12
	Total	24.36	27.72	26.66	24.09	91.01	11.65	--
Zinc	Spring	1.62	2.03	2.62	3.0	3.95	0.51	--
(lbs)	Eaton	2.64	1.15	1.86	1.63	1.80	0.50	--
	Fayette	1.57	0.95	1.27	2.26	3.17	1.45	--
	Main	0.39	0.58	1.10	1.11	2.90	0.72	--
	Oak	2.21	2.33	2.60	2.46	3.49	0.76	--
	Cedar	10.82	7.52	16.64	8.36	20.61	3.09	--
	South	4.35	2.23	3.86	3.15	10.24	2.78	0.18
	Darst	2.74	21.19	9.81	16.26	65.45	8.21	25.56
	Total	26.34	37.98	39.76	38.23	111.6i	18.02	--
Settleable Solids (ft3)	Spring	5.24	6.21	9.10	12.06	2.96	2.96	--
	Eaton	16.56	7.08	8.01	7.71	1.44	1.44	--
	Fayette	7.68	4.59	6.50	19.21	7.21	7.21	--
	Main	1.29	1.92	3.42	2.81	1.22	1.22	--
	Oak	4.46	15.93	13.56	8.05	2.69	2.69	--
	Cedar	44.13	31.94	37.42	29.29	8.79	8.79	--
	South	6.96	4.95	8.43	5.51	4.93	4.93	8.31
	Darst	11.18	90.04	34.60	45.33	29.22	29.22	103.86
	Total	97.50	162.66	120.04	129.87	58.46	58.46	--
Volatile Settleable Solids (ft^3)	Spring	1.14	1.00	1.30	2.13	2.60	0.73	--
	Eaton	0.92	0.28	0.51	0.48	0.60	0.28	--
	Fayette	2.28	0.65	1.25	6.91	3.33	2.77	--
	Main	0.10	0.11	0.17	0.23	0.33	0.26	--
	Oak	0.48	0.26	0.29	0.43	0.18	0.20	--
	Cedar	11.50	5.17	5.44	4.32	18.74	2.16	--
	South	1.16	0.33	0.61	0.62	2,67	0.60	1.02
	Darst	2.91	14.57	6.70	9.81	59.53	7.45	16.53
	Total	20.49	22.37	16.27	24.93	87.98	14.45	--

Estimated discharges from the. eight CSOs during the. August 24 storm event:

Total rainfall (inches)	*BOD_5 (lbs)*	*NH_3-N (lbs)*	*TSS (lbs)*	*Cu (lbs)*	*Pb (lbs)*	*Zn (lbs)*
2.08	24,345	191	184,833	50	91	112

It is quite obvious that the contributions from the sewers on August 24 were much greater than the loads that were discharged during the other five events. In fact the loads that occurred on that date for BOD_5, TSS, Cu, and Pb were almost equal to the combined loadings occurring during the other five events.

To determine those sewers that were major contributors in terms of the total CSOs, a factor of 100/85 was applied to the loadings and volumes shown in table 41 for each storm event . A close review of the table shows that the CSOs at Cedar Street and Darst Street contributed most of the BOD_5 (55-71%), NH3-N (60-73%), TSS (47-66%), and settleable solids (48-64%). The percentage values are estimates for the total CSOs and are not limited to the eight sewers monitored. In addition to the CSOs at Cedar and Darst streets, the CSO at South Street was an unusual contributor of heavy metals. For these three locations the estimated contributions as part of the total system for Cu, Pb, and zinc were, respectively, 56-76%, 50-71%, and 60-73%.

How do the quantities of flow from the CSOs compare to river flows? And how do the quantities of constituents from the CSOs compare to the quantities of like constituents being conveyed by the river? The IEPA employs a design streamflow which as a minimum is likely to occur once in 10 years with a duration of 7 days. It is called the 7-day 10-year low flow. This flow at Peoria is about 4900 cfs. This includes a diversion at Chicago of 1819 cfs. The dilutions afforded at the 7-day 10-year low flow for the storm events that occurred on June 28, August 24, and September 17 were computed. The dilutions that were actually available in the river during these events were also computed. The computations were based on the volumes of overflow and river flow for the duration of overflows. The observed river flows are shown in table 5.

The estimated flows from the total CSO system were derived from the sewer flow values listed in table 38 and based on the duration of these overflows as shown in table 5. The flows from the 1-74 storm flows were excluded from consideration and all observed overflows shown in table 38 were adjusted by a factor of 100/85.

The sampling effort upstream of all CSOs (transect 1 in figure 1) provided the concentrations of the constituents being conveyed by the river during each of the three storm events. With knowledge of concentration and river flow, the estimated poundage for each constituent of interest could be computed.

The resultant dilution afforded by the river in terms of stream flow to sewer flow ratios as well as the additions to the stream from the CSOs expressed as a percentage of the loads being conveyed by the stream are summarized in table 42. The assumption here is that all of the river flow is

Table 42. Stream Dilution Afforded and Relative Sewer Loads Applied to River Loads

Sampling Date	Dilution Ratio 7-day 10-yr.	Dilution Ratio Actual	Parameter	*River Load for Storm Duration (lbs)	Total Sewer Load (lbs)	% Addition to River Load
6/28	23	49	BOD_5	252,410	5,590	2.21
			Ammonia	7,801	60	0.77
			**Cadmium	--	--	--
			Lead	1,282	29	2.30
			Zinc	4,848	31	0.64
			Copper	1,114	9	0.80
			Suspended Solids	3,844,660	57,711	1.50
8/24	7	12	BOD_5	192,605	28,641	14.87
			Ammonia	7,184	225	3.13
			**Cadmium	--	--	--
			Lead	1,014	107	10.55
			Zinc	1,454	131	9.00
			Copper	881	59	15.49
			Suspended Solids	2,278,645	217,450	9.54
9/17	91	122	BOD_5	167,952	6,068	3.61
			Ammonia	7,117	98	1.38
			**Cadmium	—	--	--
			Lead	711	14	1.97
			Zinc	712	21	2.95
			Copper	711	9	1.27
			Suspended Solids	1,448,227	19,071	1.32

* Average Load Measured at Transect 1
** Below detection limits

available for dilution purposes. This is not necessarily the case but in the absence of a mixing zone definition it will suffice.

Table 42 demonstrates the magnitude of the August 24 storm. Dilution ratios for the other two storm events varied from 49:1 to 122:1 during observed conditions. For similar conditions the dilution ratios for the 7-day 10-year low flow were 23:1 and 91:1.

However for the August 24 event with estimated overflows of about 696 cfs the dilution ratio during observed conditions was about 12:1 with a ratio of 7:1 during the 7-day 10-year minimum flow.

The contributions of the various constituents from the CSOs to the river load were quite variable and patternless for each of the three events. During June 28 and September 17 there were no recorded additions from the CSOs in excess of 4 percent of the river load. However the once-in-10-years storm on August 24 added about 15, 10, and 15 percent of the BOD5, lead, and copper loads in the river, respectively.

It is realized that dilution ratios and percent additions do not represent all the factors germane to the influence of waste flows on the water quality of a receiving stream. Nevertheless, using the August 24 storm event as a basis, the dilution spread of 1:3:13 (7:23:91) for the 7-day 10-year low flow and 1:4:10 (12:49:122) for observed conditions encompasses a considerable spectrum of CSOs to river flow conditions. And the absence or existence of significant water quality degradation within these ranges at Peoria suggests that the limits of dilution ratios observed may be of value for predicting likely conditions for other communities along the Illinois River.

SUMMARY AND CONCLUSIONS

This study was very comprehensive. Sampling and analyses were performed on Illinois River waters and sediments as well as on selected combined sewer overflows. Water samples were collected at four transects during three storm events and two dry weather periods. One transect was located upstream of all combined sewer overflows, two were located within the area of overflows, and one was located downstream of all overflows. Samples were collected from bank to bank on the horizontal and at selected stations on the vertical at 30-minute intervals during storm events. During these periods river flows ranged from 6600 to 10,335 cfs. During the in-stream work about 1040 samples were recovered, requiring 11,450 field measurements and laboratory analyses. Water samples were examined for pH, temperature, turbidity, and concentrations of dissolved oxygen, ammonia-nitrogen, cadmium, copper, lead, zinc, suspended solids, grease, oil, fecal coliform bacteria, and biochemical oxygen demand.

River bottom sediments were collected on two occasions at 28 locations. Three of the sites were located upstream of all combined sewer overflows and one was located downstream of all overflows. Nineteen sites were established in the vicinity of overflows and five were located on the East Peoria side of the river. Analyses were performed for particle size distribution, moisture and volatile solids content, and concentrations of cadmium, copper, lead, zinc, and grease and oil.

Macroinvertebrate collections were taken from the bottom sediments at 19 sites. Three bottom sediment sites were located upstream of all overflows and one downstream of all overflows. Ten locations were selected in the vicinity of overflows and five sites were established on the East Peoria side of the river. At these sites sediment oxygen demand measurements were performed also.

Flow measurements and sequential sampling of combined sewer overflows were performed at eight CSOs during seven storm events. Also included for examination was a storm sewer. About 535 samples were collected from the overflows, requiring 6385 analyses. Examinations were performed for pH, fecal coliform densities, and concentrations of ammonia-nitrogen, settleable solids, volatile settleable solids, suspended solids, biochemical oxygen demand, cadmium, copper, lead, and zinc. The sewers monitored probably produced about 85 percent of the total combined sewer overflows emanating from the combined sewer system serving the City of Peoria.

The intensities of the three storms that occurred during the in-stream sampling were 1.09, 1.44, and 0.33 inches per hour with a total rainfall, respectively, of 1.16, 2.08, and 0.64 inches. The duration of overflows for these storms ranged from 136 to 218 minutes.

An evaluation of the data developed from the analyses of water samples collected from the Illinois River during the three storm events shows that the only significant violation of water quality standards that can be attributed to combined sewer overflows and defined by a numerical limit is fecal coliform densities.

Dissolved oxygen generally ranged from 6 to 9 mg/l. The pH was within a narrow range of 7.5 to 8.7. The maximum value of 0.89 mg/l for total ammonia-nitrogen is considerably less than the maximum limit of 1.5 mg/l. There were no significant changes in water temperature. With the exception of a few transitory elevations, concentrations of cadmium, lead, and zinc were well within allowable limits. Copper concentrations on the other hand exceeded the limit of 0.02 mg/l frequently during dry weather periods as well as wet weather periods, but on the average the difference in concentration between these periods was not significant. The contribution of overflows to suspended solids and turbidity within the stream was not significant compared to that originating from small watercourses and overland drainage. Grease and oil concentrations were higher at several locations in the river during overflow events than during dry weather stream flows. However the random occurrence of these higher concentrations in terms of time and location precluded any effort to define the primary sources. Total biochemical oxygen demand concentrations were of equal magnitude for both sides of the river, suggesting that overland urban drainage and other discharges were as significant a source as combined sewer overflows.

Fecal coliform densities, however, exceeded the water quality standard of 200 per 100 ml frequently during overflow events. Maximum densities in excess of 100,000 per 100 ml frequently occurred near-shore on the Peoria side of the river. Visual inspections also revealed considerable floating debris consisting mainly of grass clippings, styrofoam food containers, and soda cans but also including condoms, oil skim, and undefinable trash.

The bottom sediments in the vicinity of combined sewer overflows were primarily sand or a mixture of sand and rock. There were no sludge accumulations of sewage origin detected during the study. There was evidence that the bottom sediments of the river in the vicinity of overflows were impacted by the overflows. This was apparent from elevations in concentrations of grease and oil, zinc, and lead. However it is likely that the elevated concentrations detected are related more to characteristics of urban drainage, in the absence of sewage, than to combined sewer overflow. By this is meant that the principal sources of grease and oil, lead, and zinc occurring in the bottom sediments are roof and street drainage rather than the sewage components of combined sewer overflows.

The bottom dwelling organisms recovered from the river's sediment are typical of those residing in the Peoria and LaGrange navigation pools. The densities observed were not of the magnitude typical of significant organic enrichment. The limiting factor for the development of a well diversified macroinvertebrate population is likely the unstable habitat compounded by excessive waves (from barges and wind) rather than water quality.

The impact of the overflows on the sediments as measured by sediment oxygen demand was limited to five locations, all within the region of lower Peoria Lake. The average demand of 2.61 grams/m^2/day at these stations represents moderately polluted conditions.

Flow measurements at the sewers suggest that the overflows at Darst and Cedar Streets produce about 63 percent of the measured combined sewer overflows. These installations also release about 50 to 70 percent of the measured load for biochemical oxygen demand, ammonia-nitrogen, total suspended solids, and settleable solids. Those sewers in combination with the South Street overflow produce about 50 to 75 percent of the measured load for copper, lead, and zinc.

During the three storm events (June 28, August 24, and September 17) that were monitored in the river the dilution ratios (river flow:CS0) were 49, 122, and 12, respectively. Except for the August 24 event, which was a once-in-10-years rainfall occurrence, the contribution of the combined sewer systems to the river did not exceed 4 percent of the biochemical oxygen demand, ammonia-nitrogen, suspended solids, and heavy metals (cadmium, copper, lead, and zinc) in the river. On August 24 the combined sewer contribution for these same constituents ranged from 10 to 15 percent of that being transported by the river.

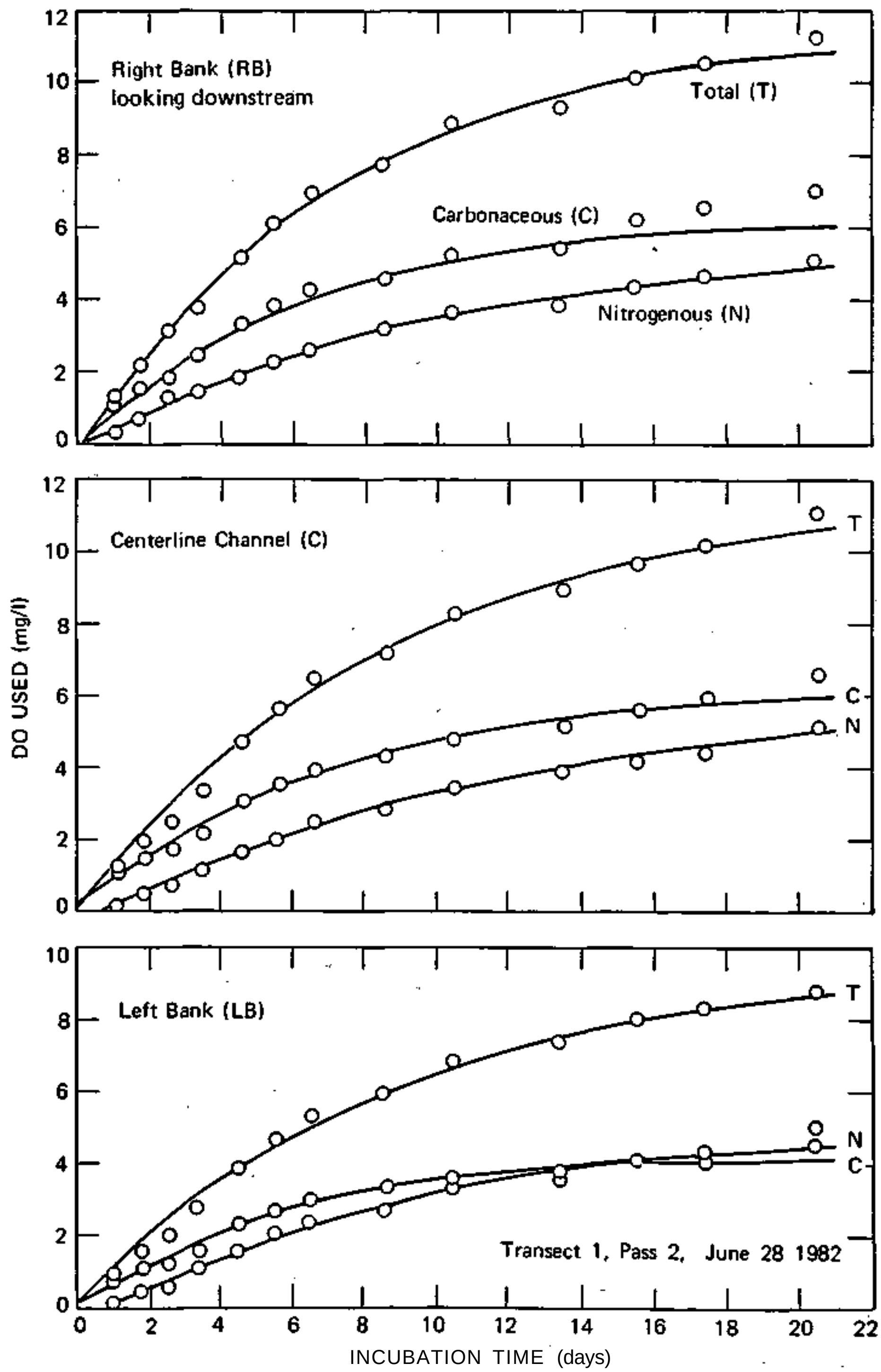
An ideal pattern of load release or of load magnitude does not exist for the combined sewer system serving the City of Peoria. Thus there is not a single conceptual model that would be useful for predicting the first flush phenomenon.

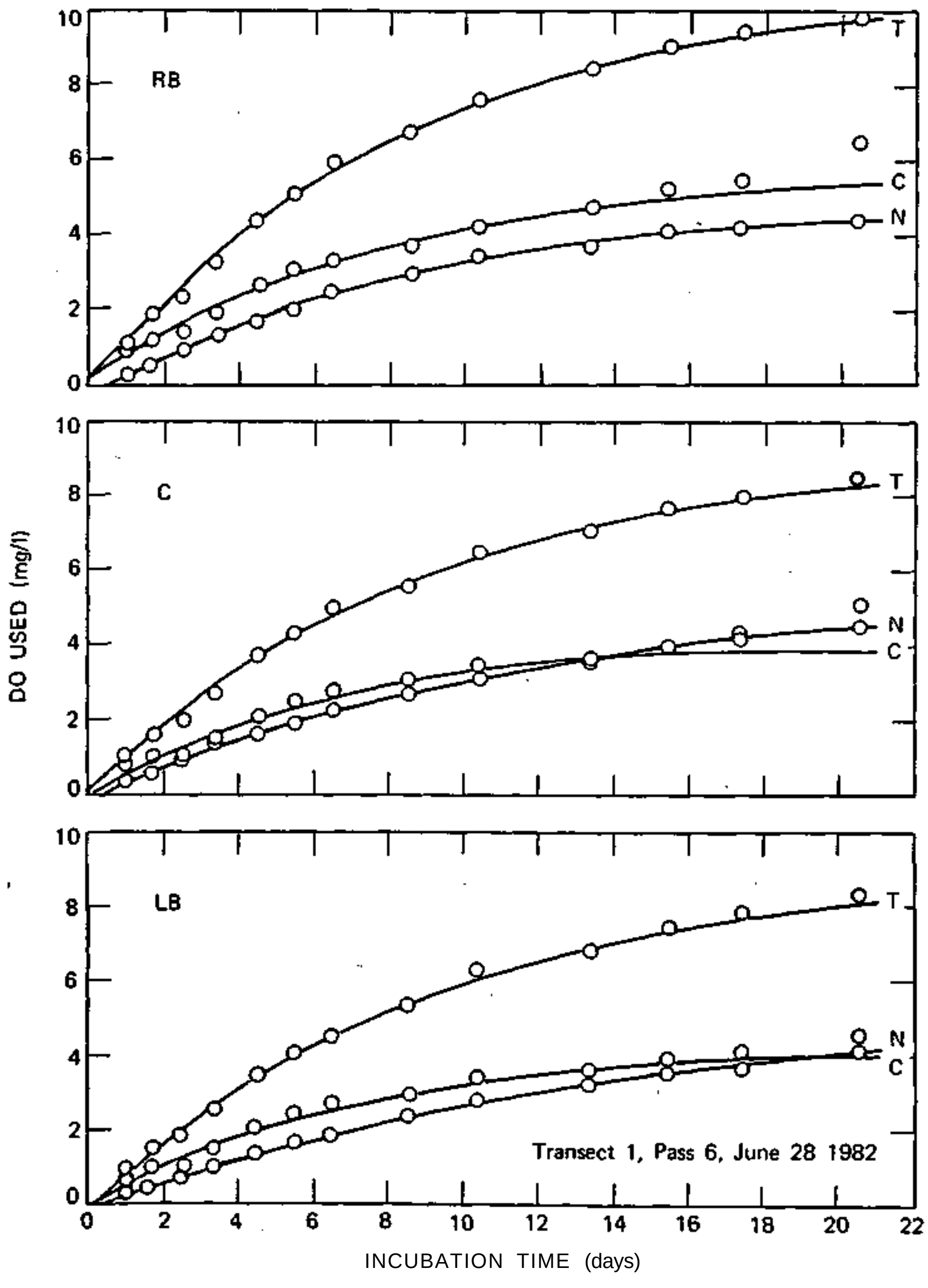
The conclusions derived from this study are as follows:

- The data developed are representative of a reasonable range of rainfall intensities and a wide range of river dilution ratios. Under such conditions the observations gained should be applicable with a high degree of confidence and probability.
- Although the impacts of the combined sewer overflows on the water and sediments of the Illinois Waterway were detectable by various measurement procedures, the only significant impacts related solely to the combined sewer overflows were substantial increases in fecal coliform densities and the transitory occurrences of floating debris — both inconsistent with water-related recreation and riverfront development.
- If remedial measures are required, the site-specific examinations of the flows and quality of the combined sewer overflows performed during the course of this study should provide the basis for a confident undertaking.

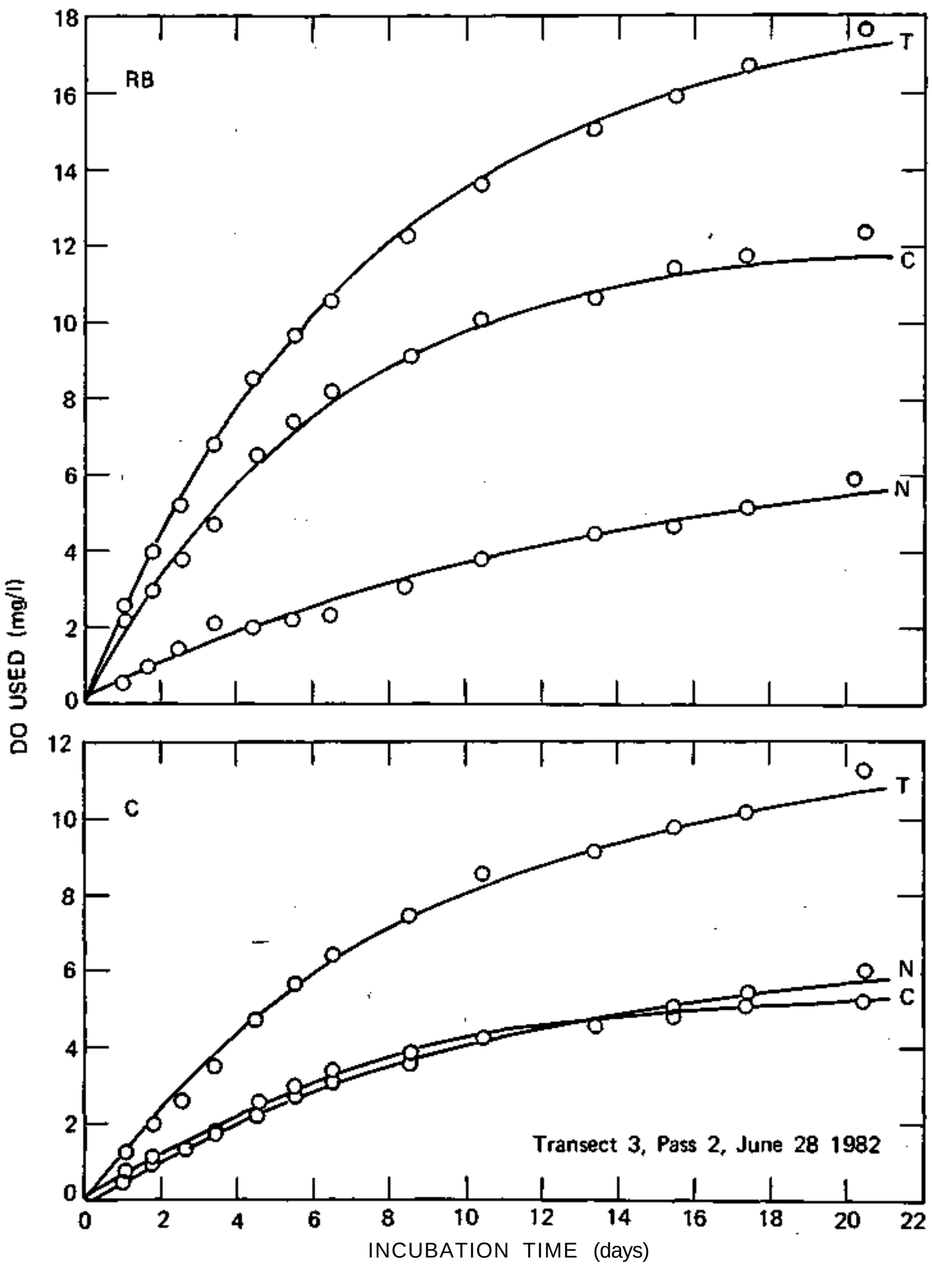
Appendix A

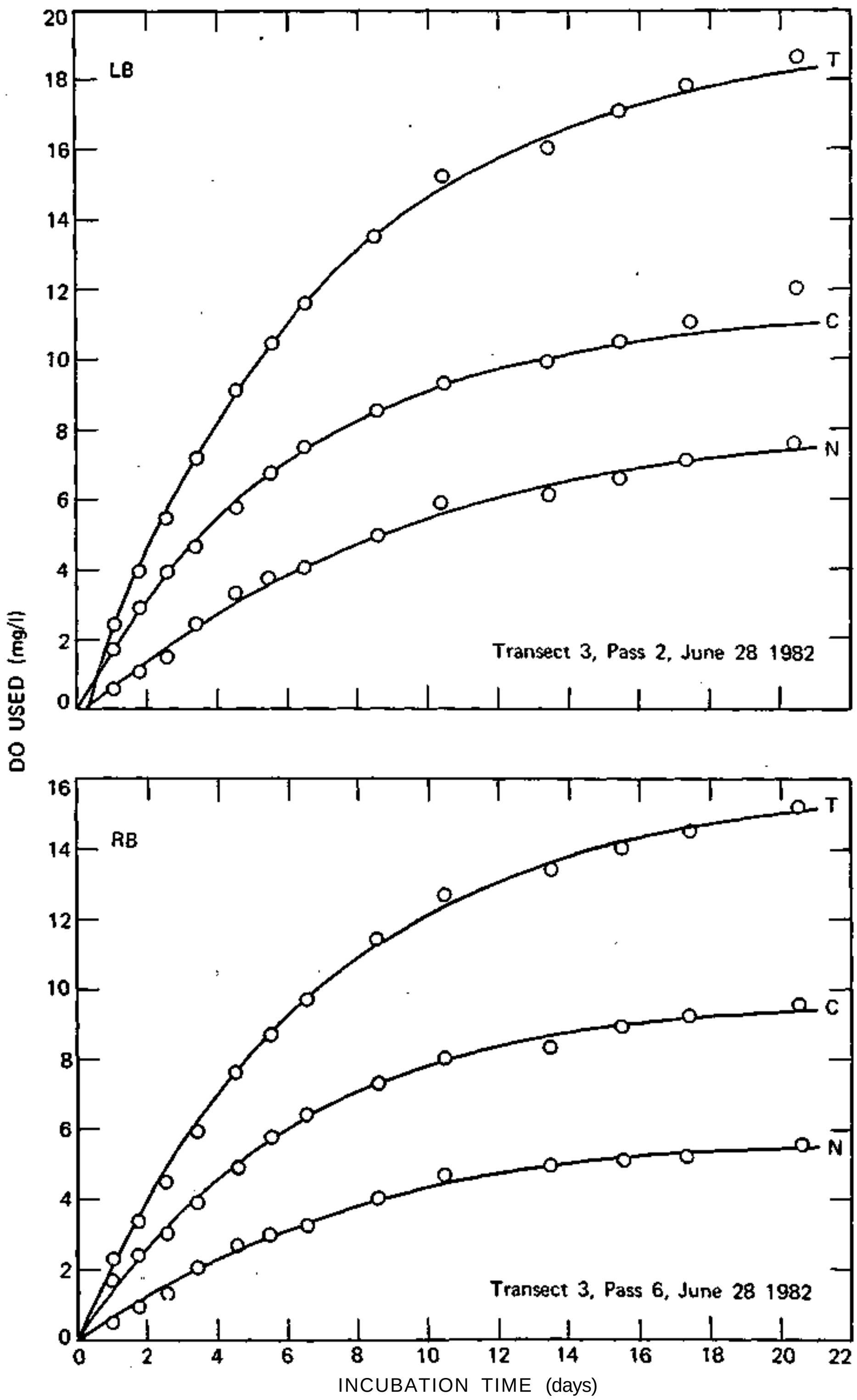
Typical BOD Progression Curves,
Based on Data for June 28, 1982


Right Bank (RB)
looking downstream
Total (T)
Carbonaceous (C)
Nitrogenous (N)
Centerline Channel (C)
T
C
N
Left Bank (LB)
T
N
C
Transect 1, Pass 2, June 28 1982
DO USED (mg/l)
INCUBATION TIME (days)
0
2
4
6
8
10
12
14
16
18
20
22

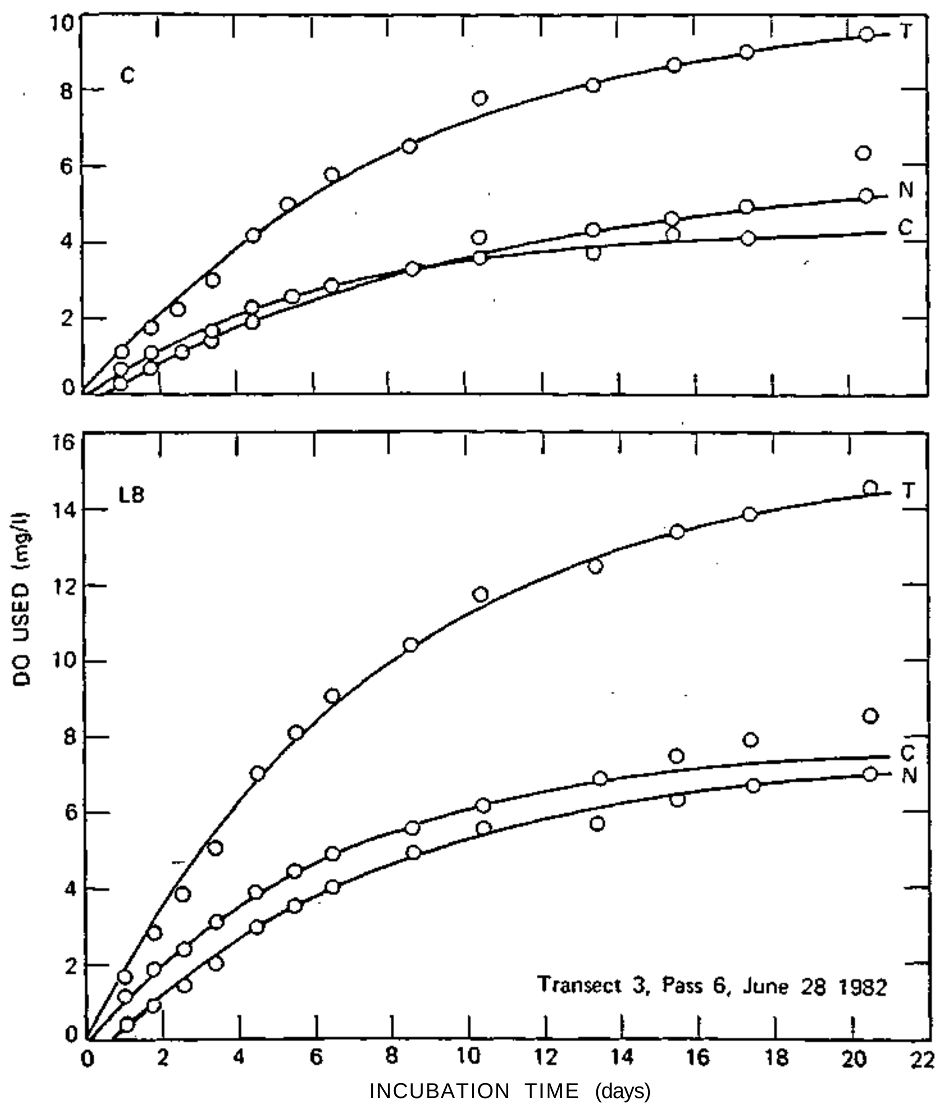


RB
C
LB
T
C
N
T
N
C
T
N
C
Transect 1, Pass 6, June 28 1982
DO USED (mg/l)
INCUBATION TIME (days)
0
2
4
6
8
10
12
14
16
18
20
22

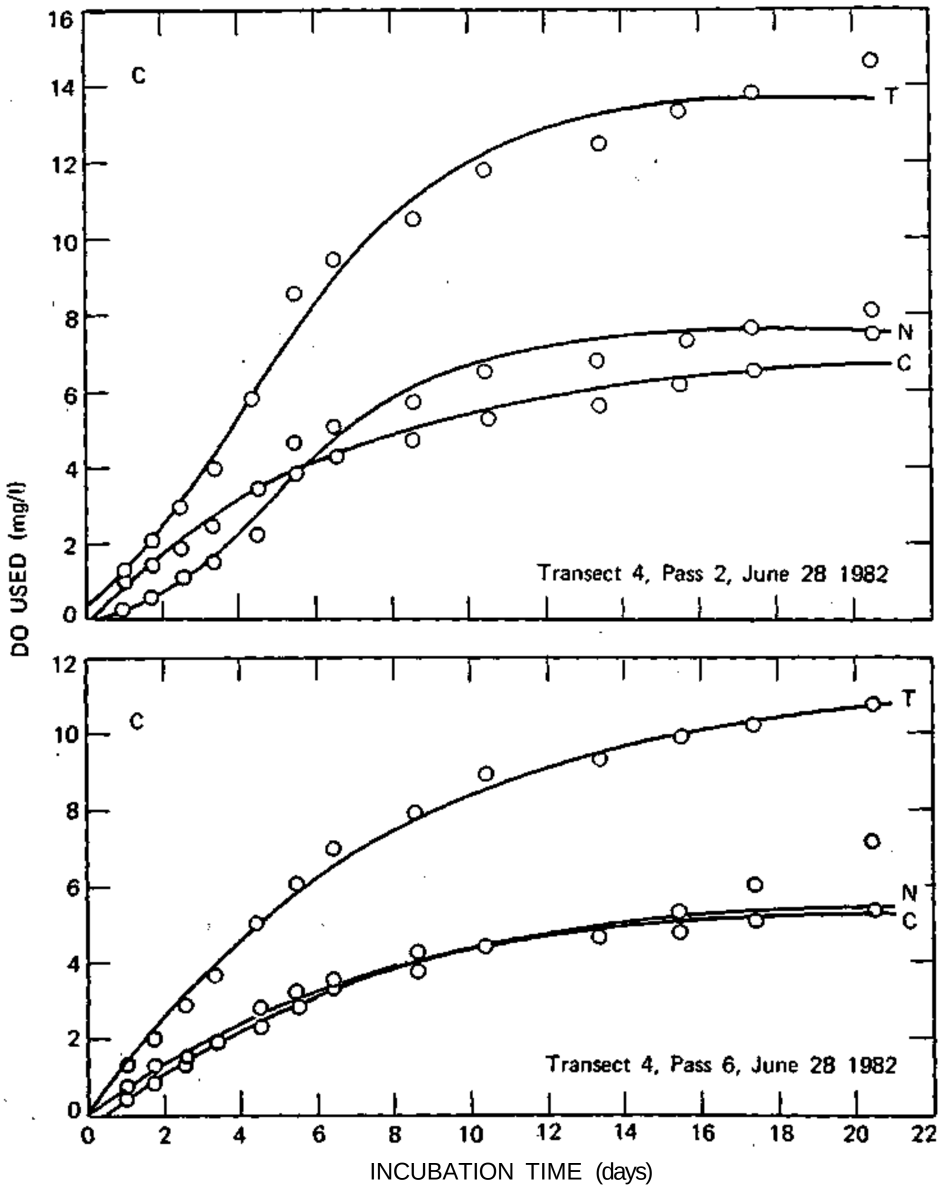

RB
T
C
N
C
T
N
C
Transect 3, Pass 2, June 28 1982
DO USED (mg/l)
INCUBATION TIME (days)



LB
T
C
N
Transect 3, Pass 2, June 28 1982
DO USED (mg/l)
RB
Transect 3, Pass 6, June 28 1982
INCUBATION TIME (days)

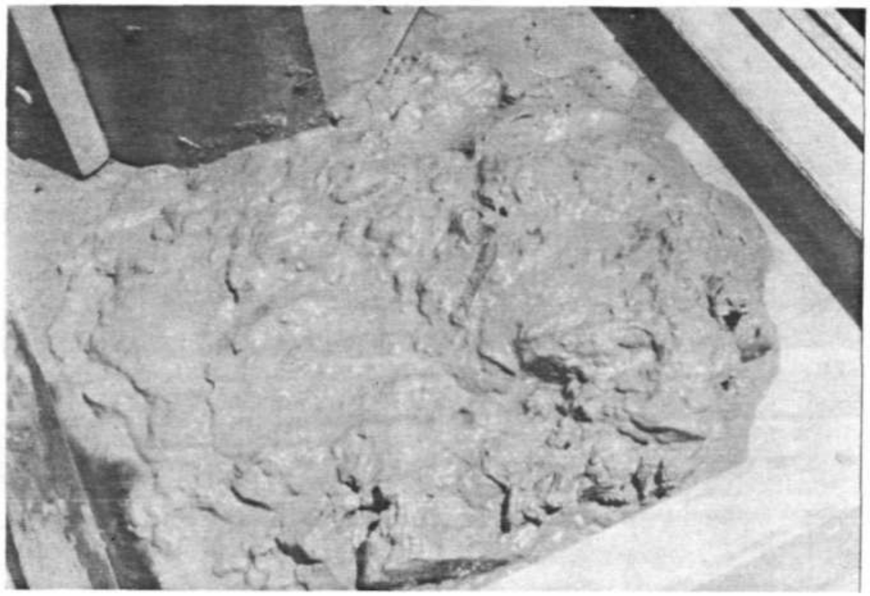


C
T
N
C
LB
T
C
N
DO USED (mg/l)
Transect 3, Pass 6, June 28 1982
0
2
4
6
8
10
12
14
16
18
20
22
INCUBATION TIME (days)

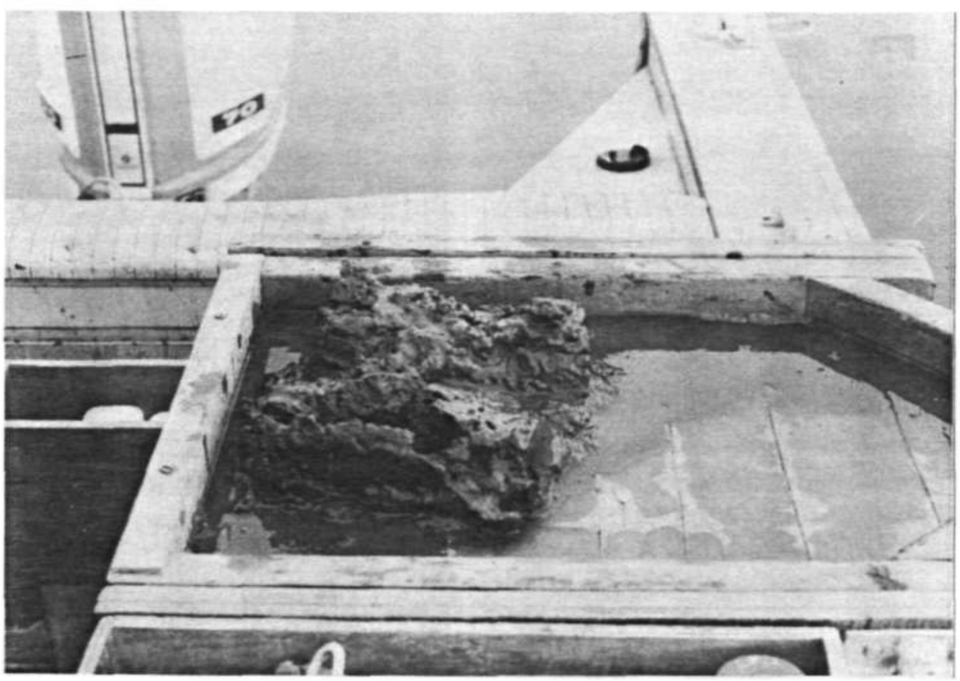

C
Transect 4, Pass 2, June 28 1982
T
N
C
C
Transect 4, Pass 6, June 28 1982
T
N
C
DO USED (mg/l)
INCUBATION TIME (days)

Appendix B

River Bottom Sediments Collected
at 28 Locations, July 1982 and March 1983
(Photographs)

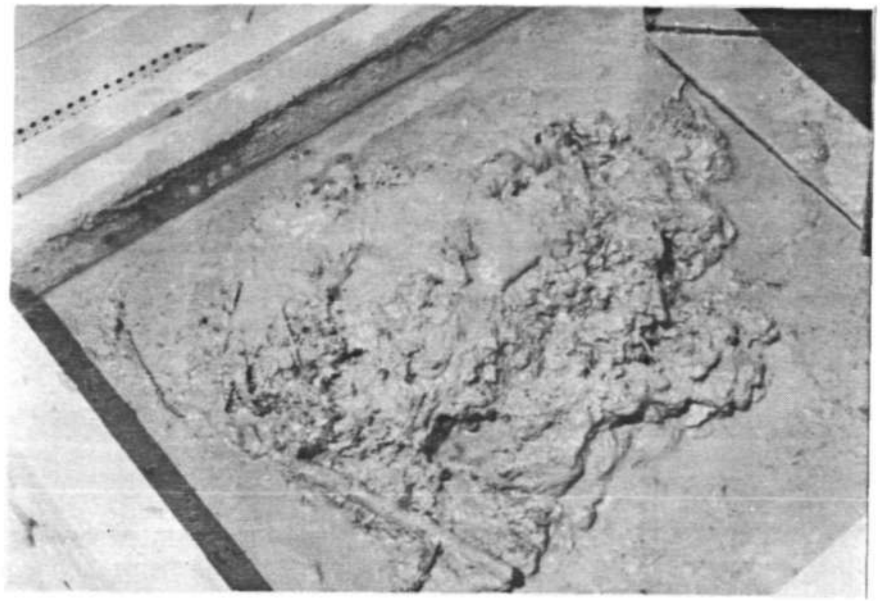


7/1,2/82



3/1/83

Station 1



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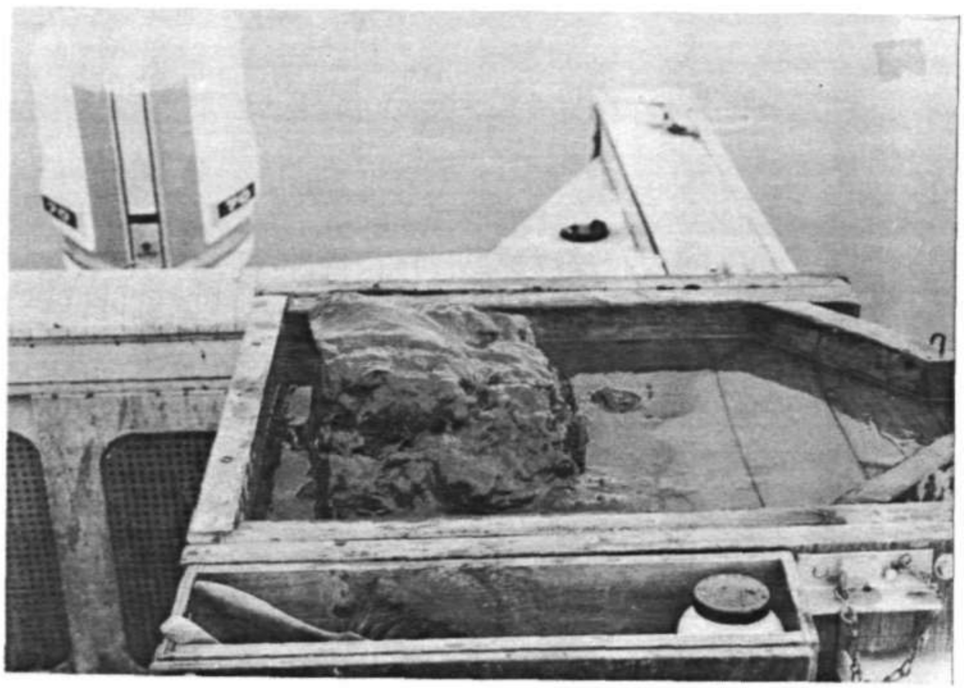
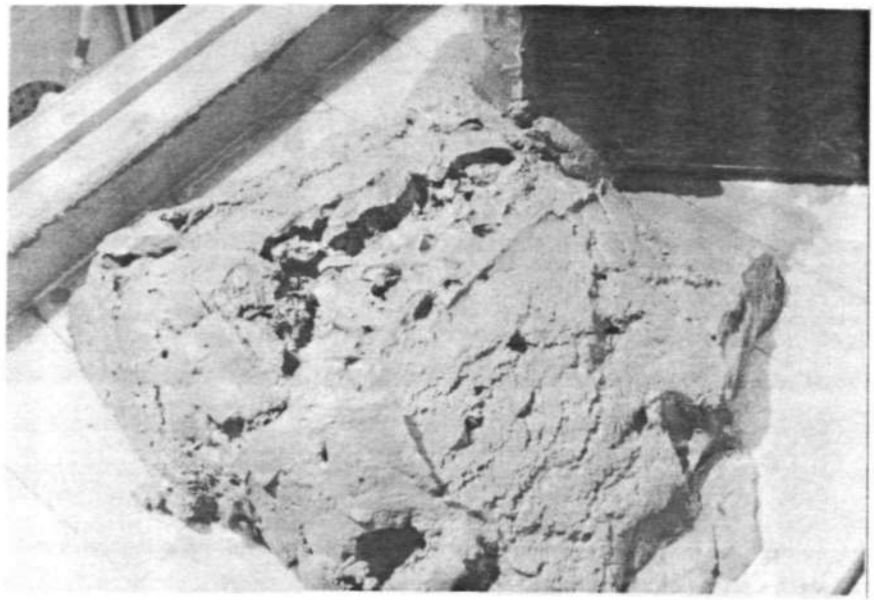


3/1/83

Station 2



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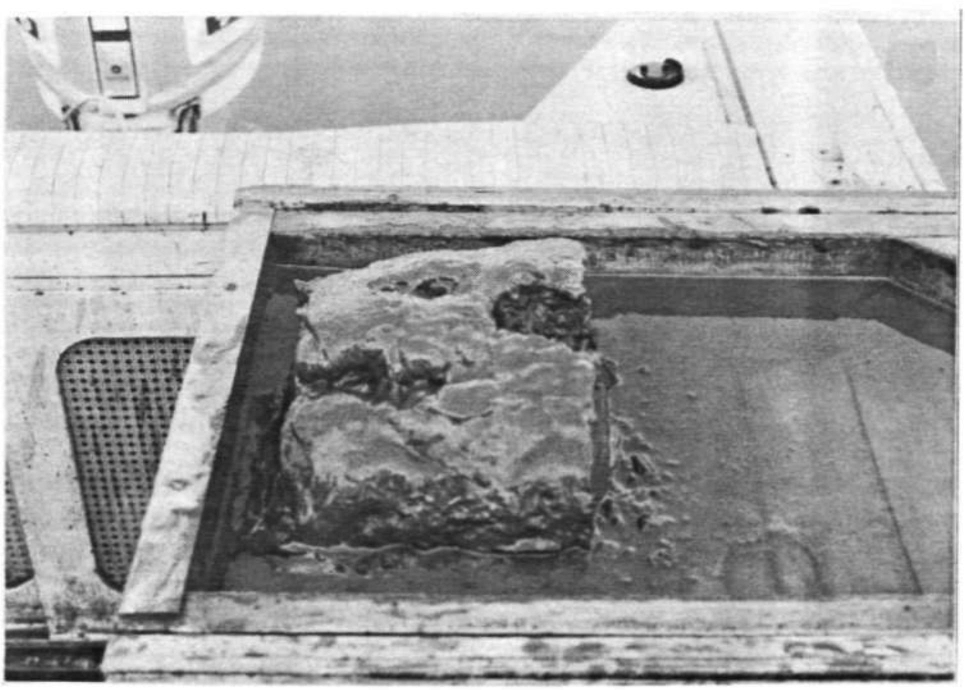
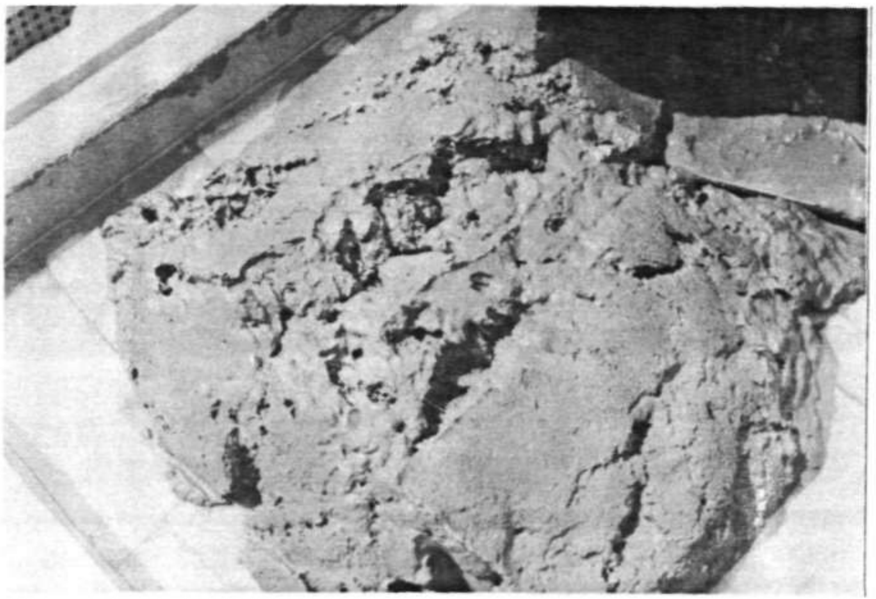


3/1/83

Station 3



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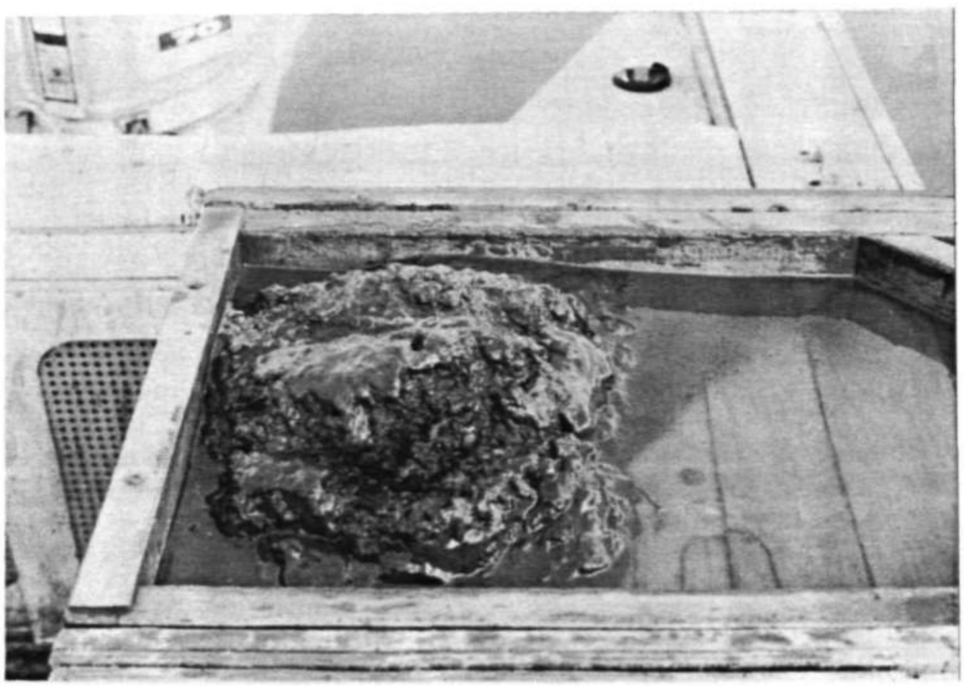

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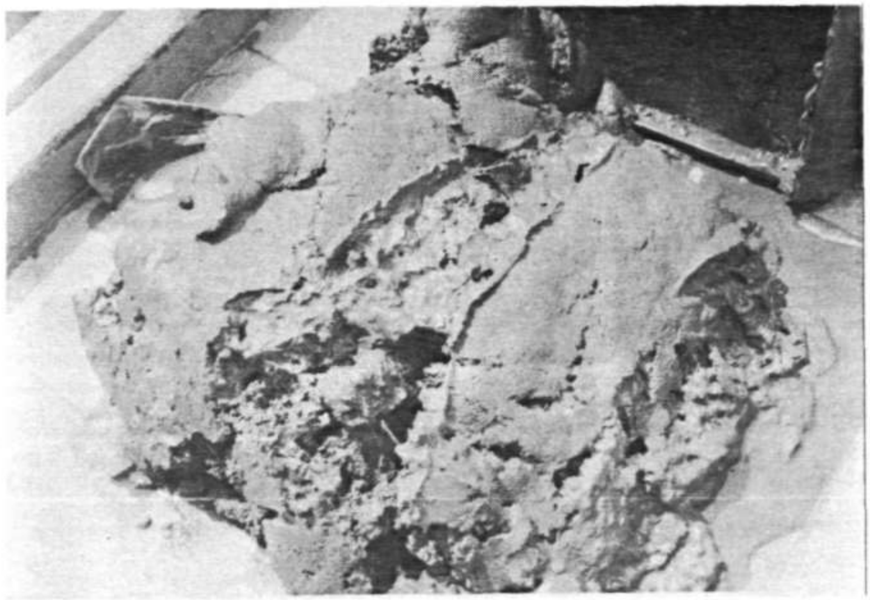

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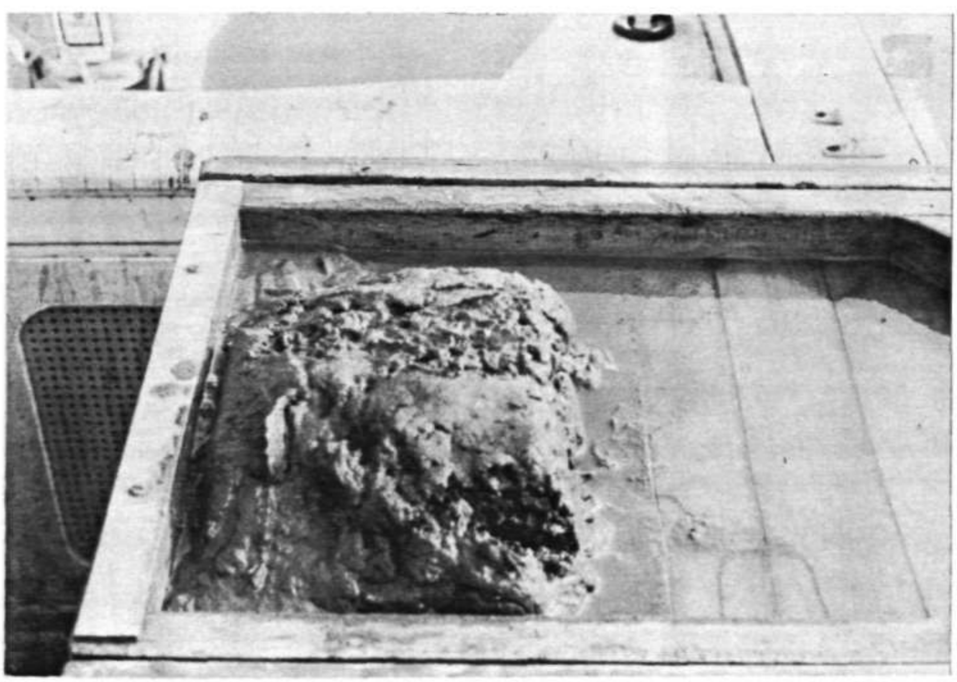
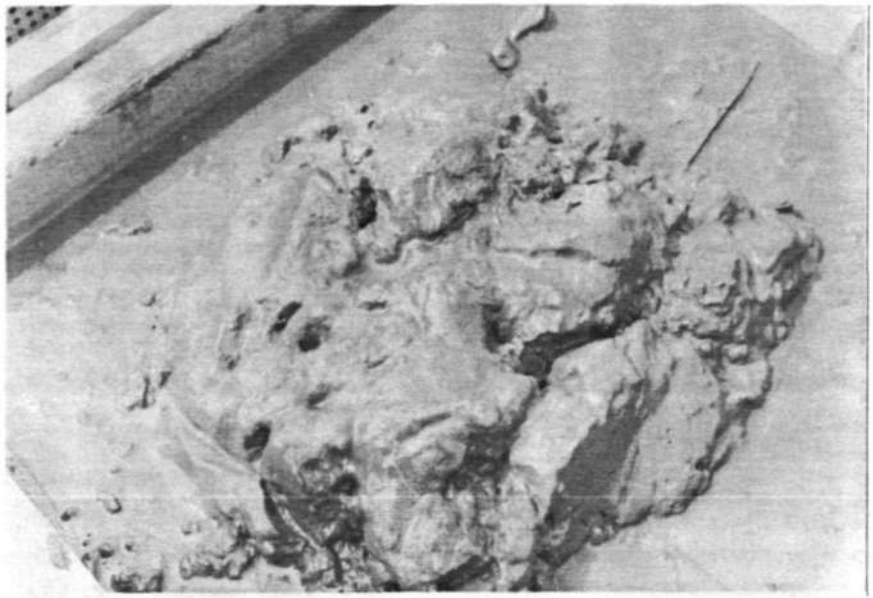


3/1/83

Station 5



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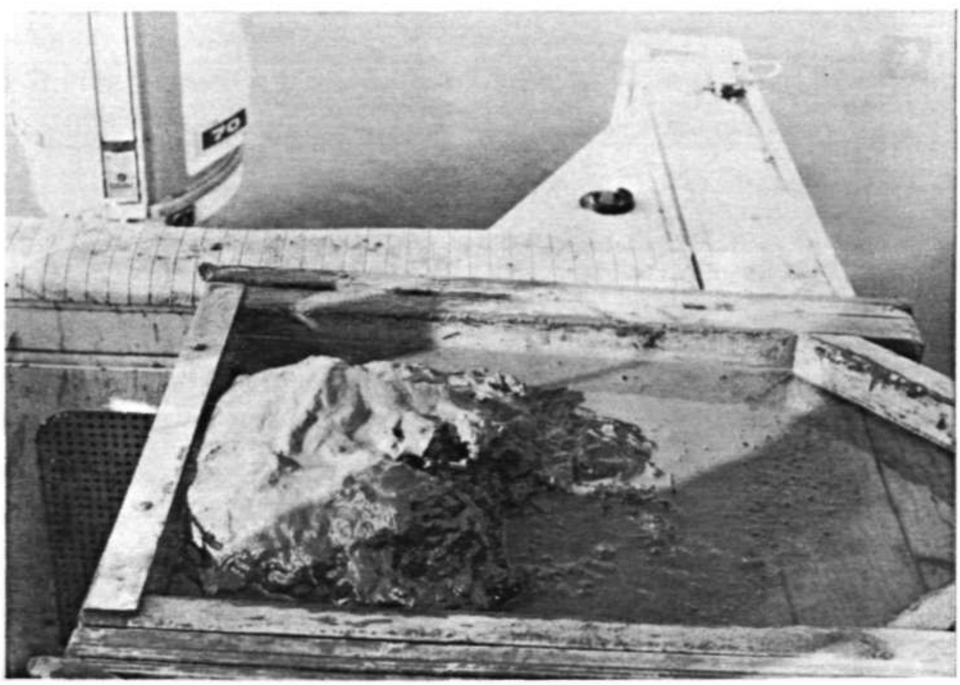

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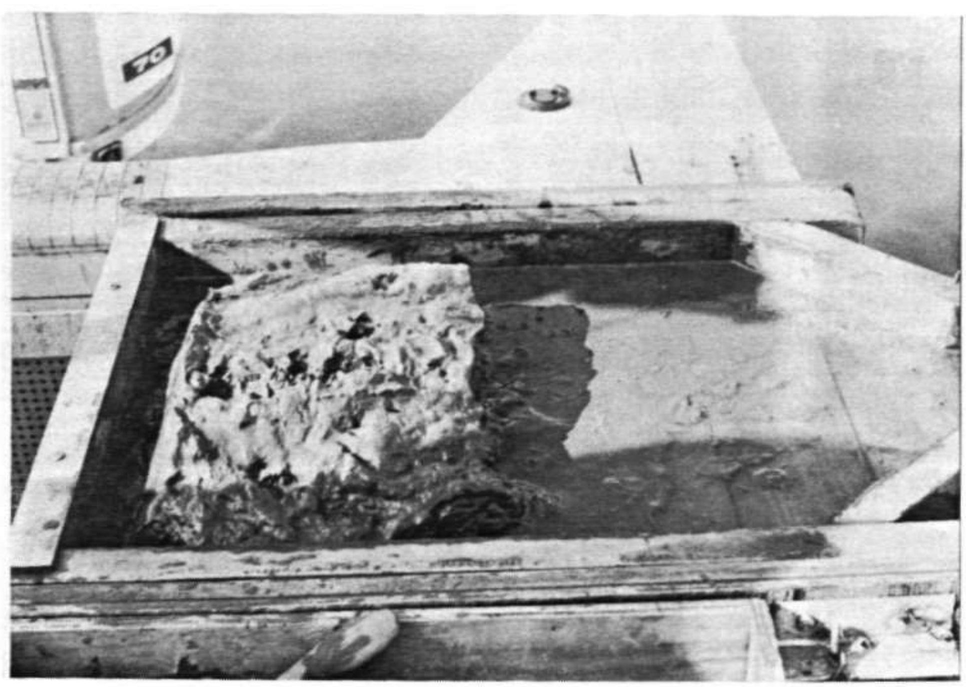
Station 6

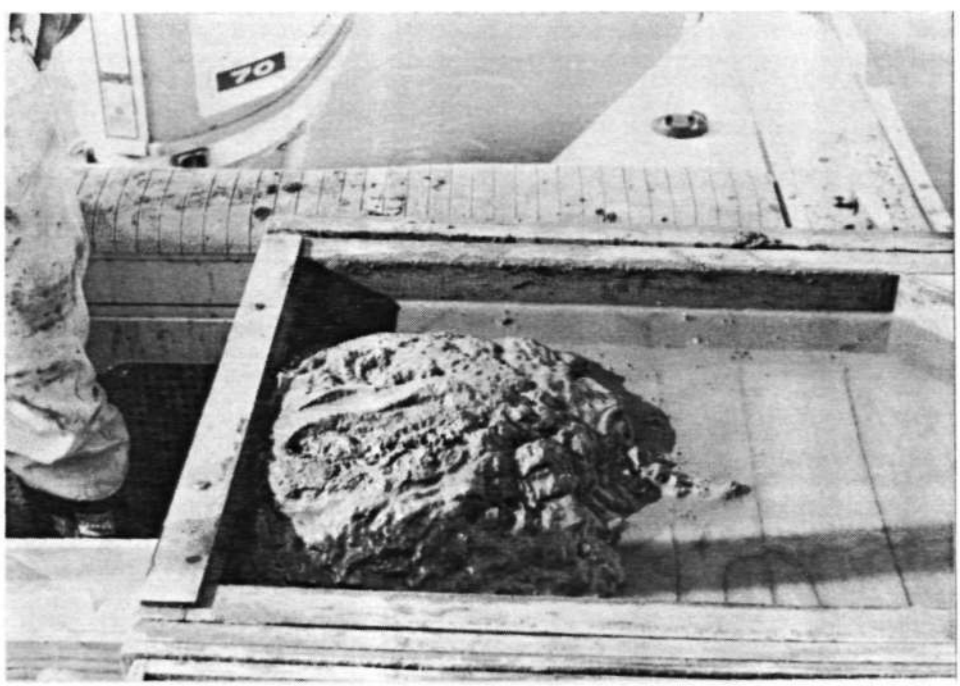
7/1,2/82



3/1/83

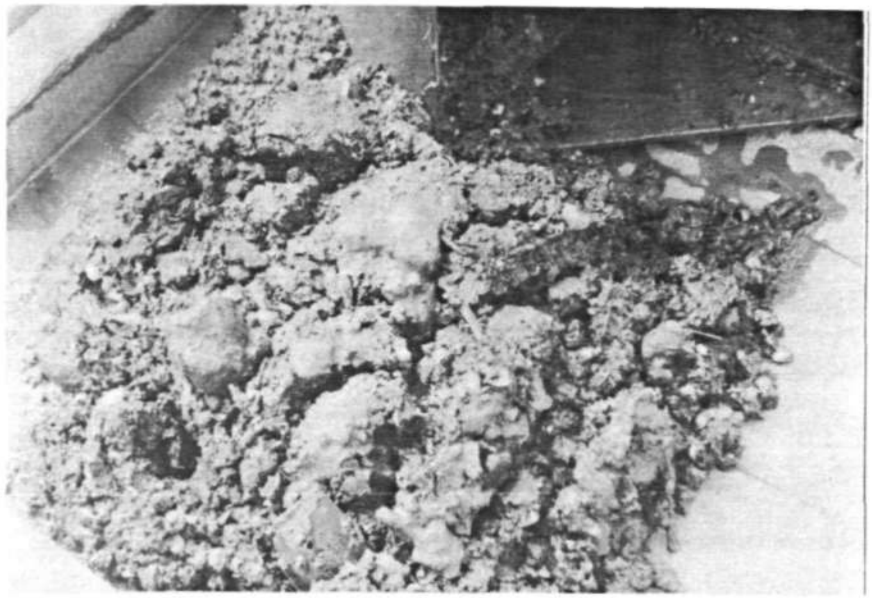
Station 7

7/1,2/82



3/1/83

Station 8



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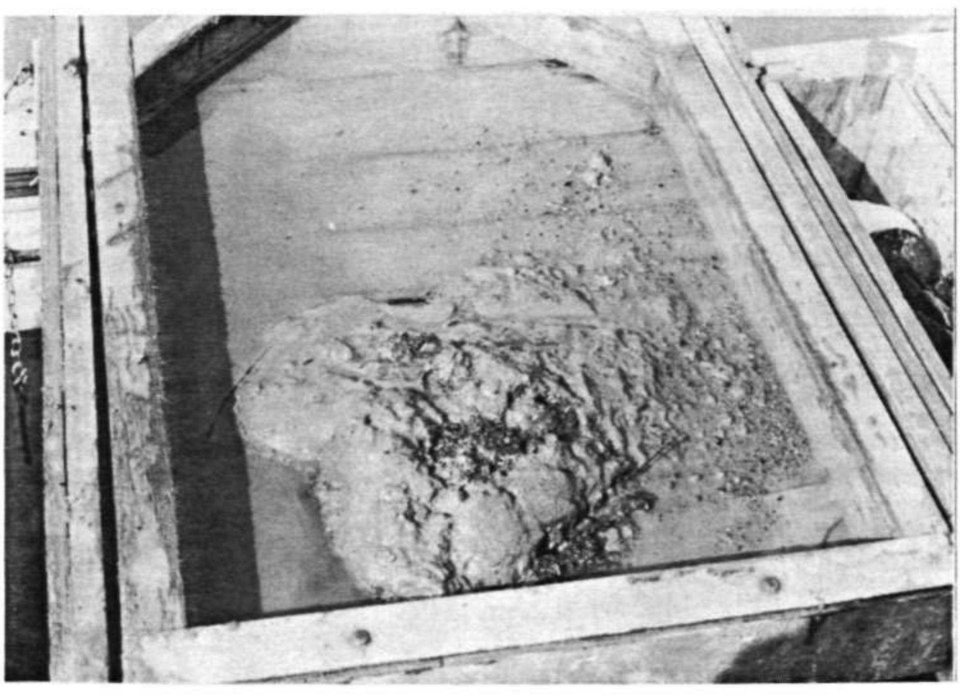
3/1/83

Station 9

7/1,2/82



3/1/83

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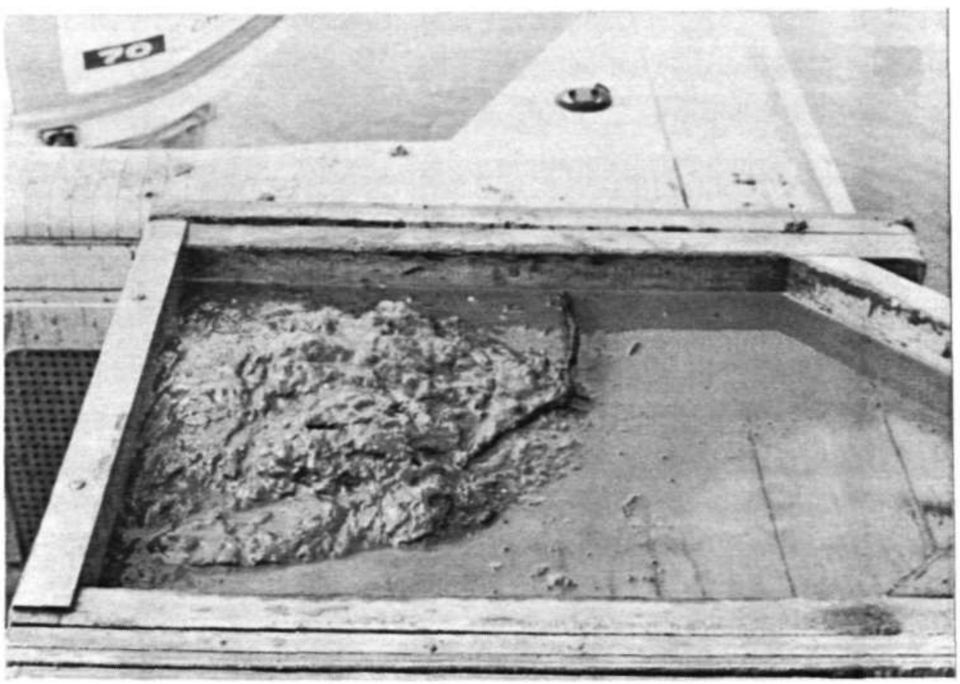
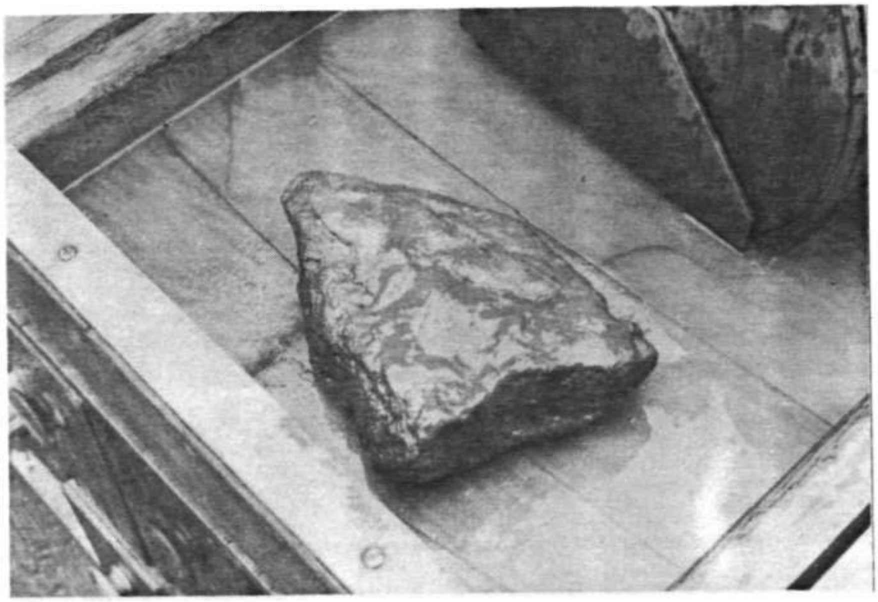
7/1,2/82



3/1/83

Station 11



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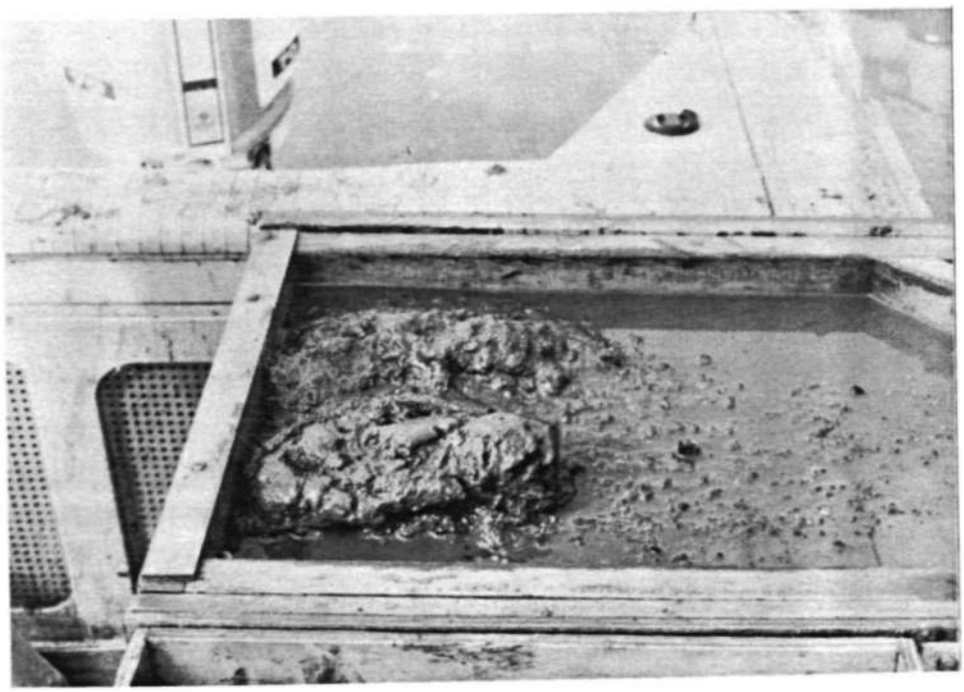
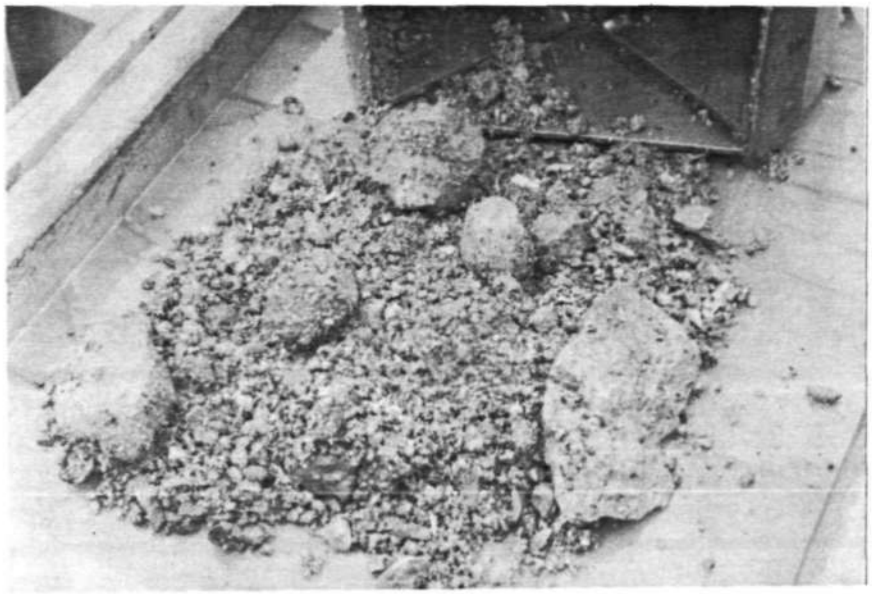


3/1/83

Station 12



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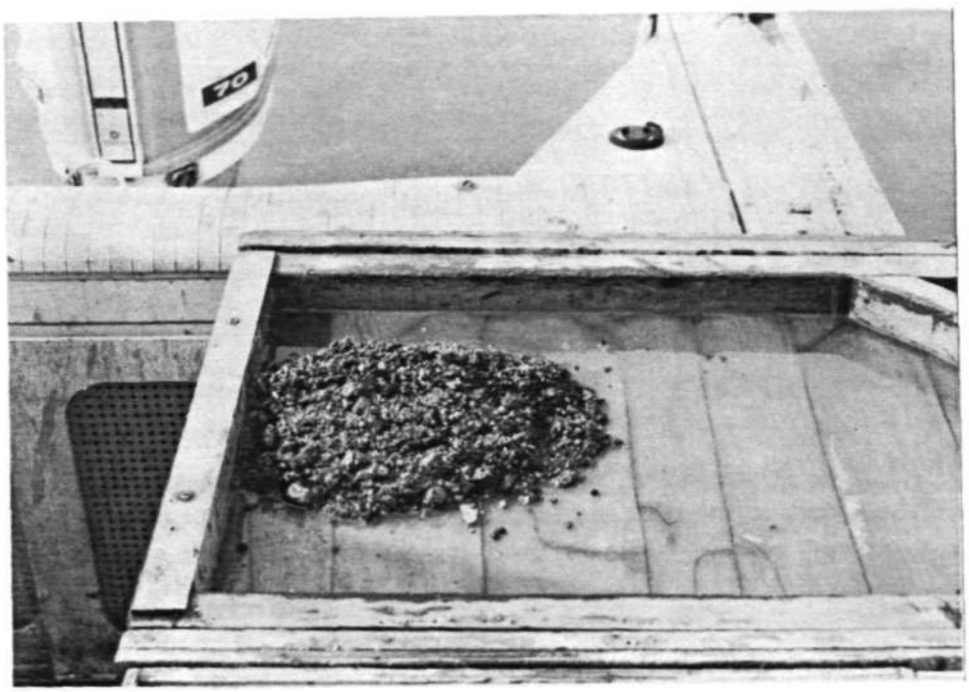
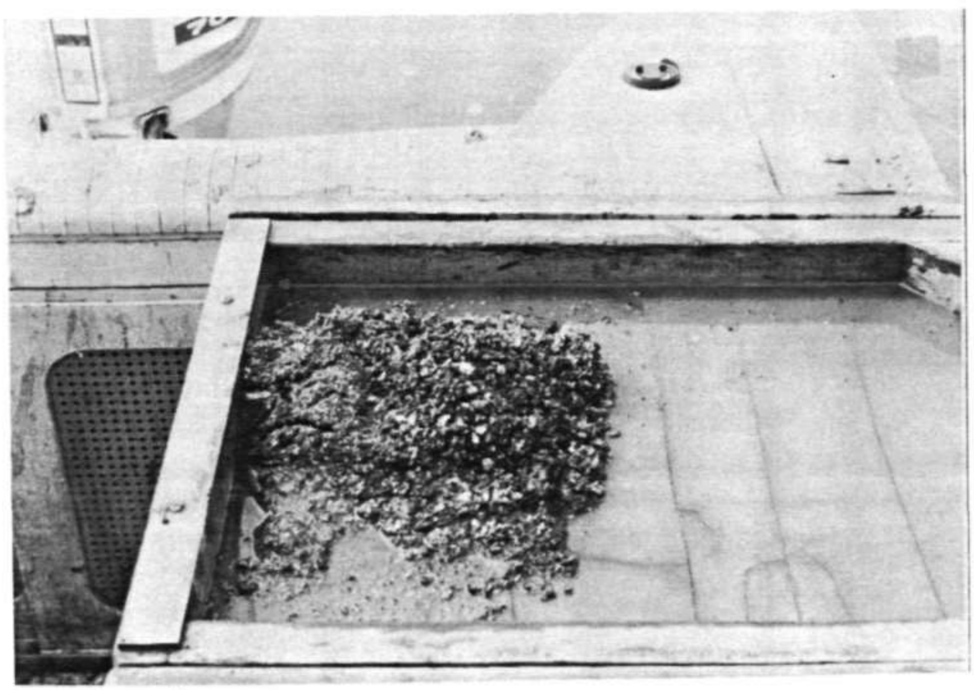


3/1/83

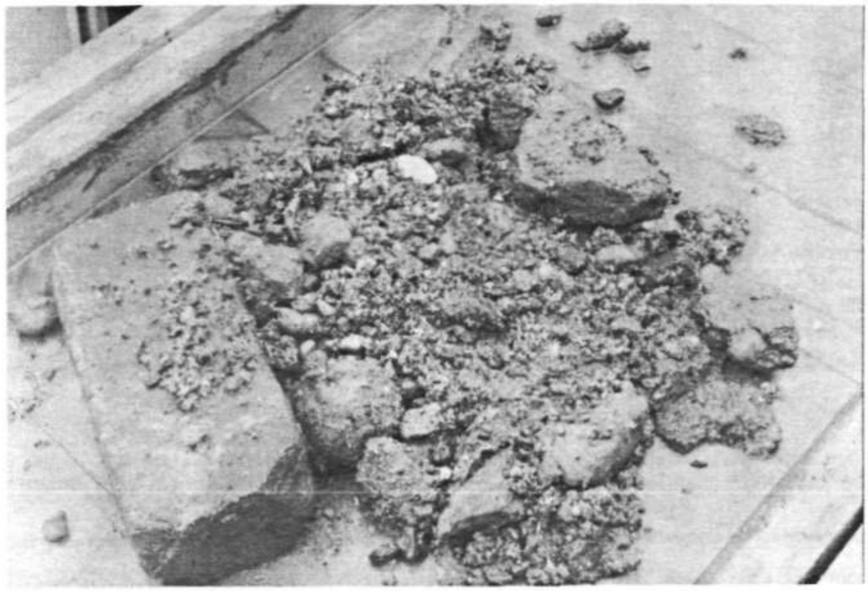
Station 13

7/1,2/82

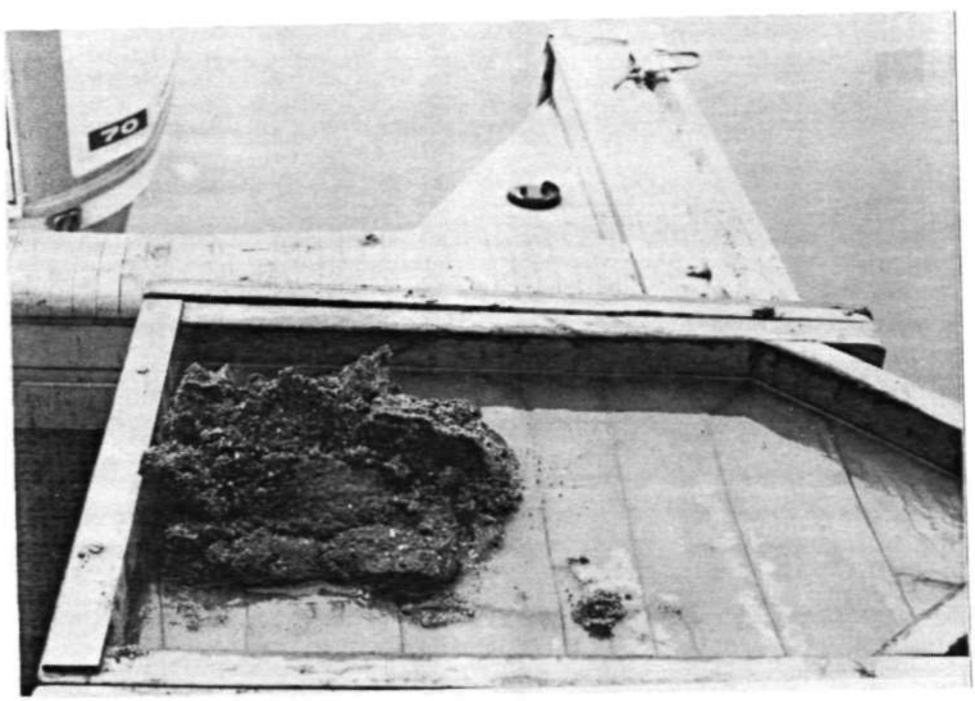


3/1/83

Station 14



7/1,2/82



3/1/83

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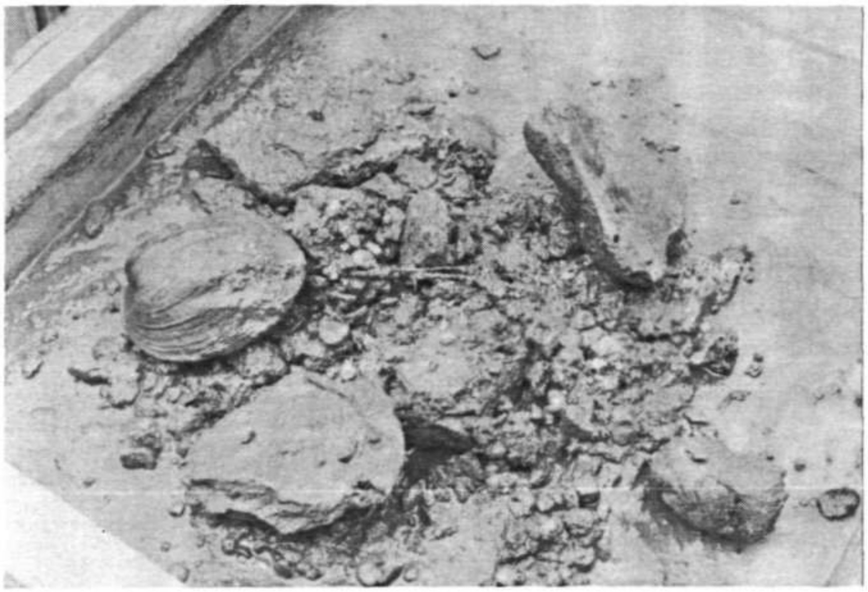
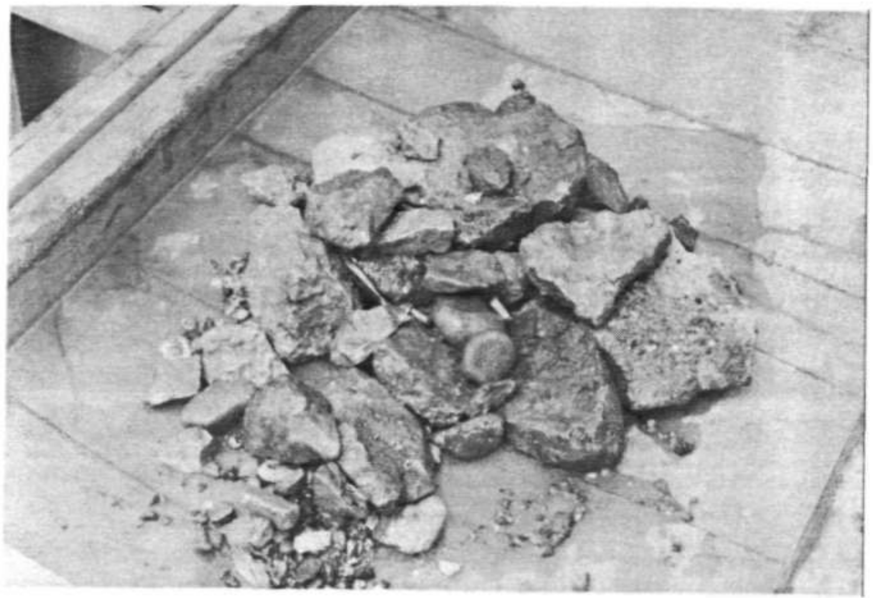


7/1,2/82

3/1/83

Station 16



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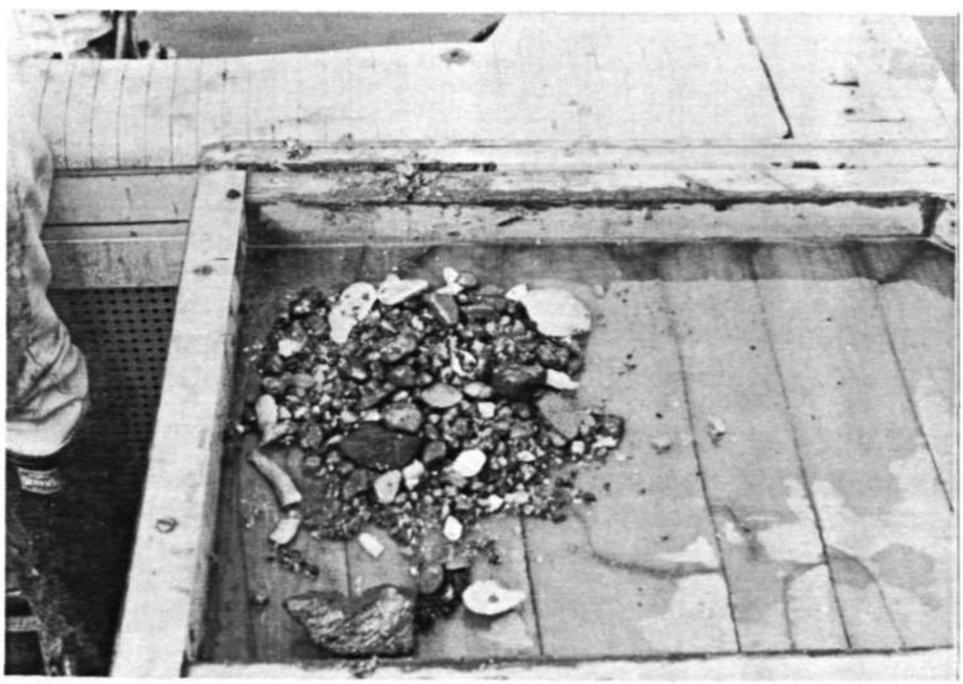

3/1/83

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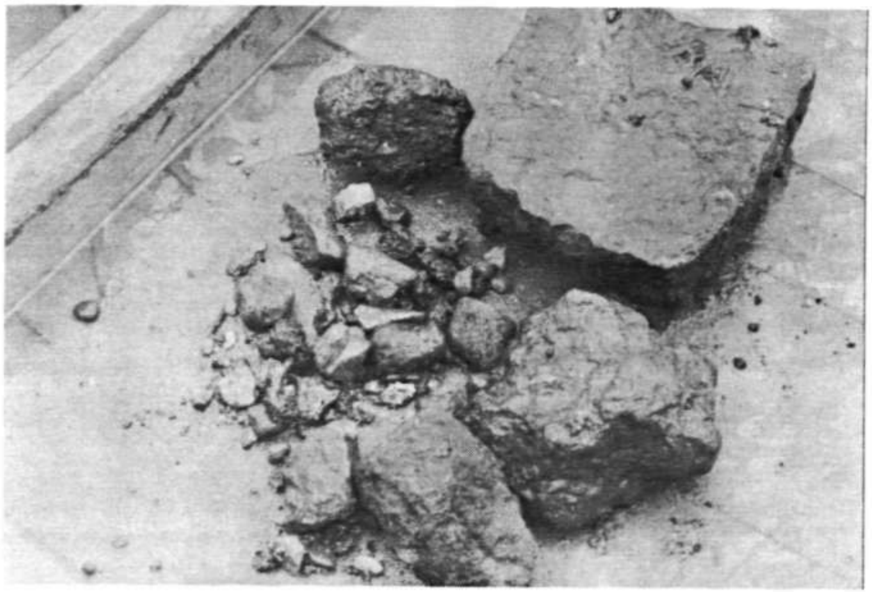
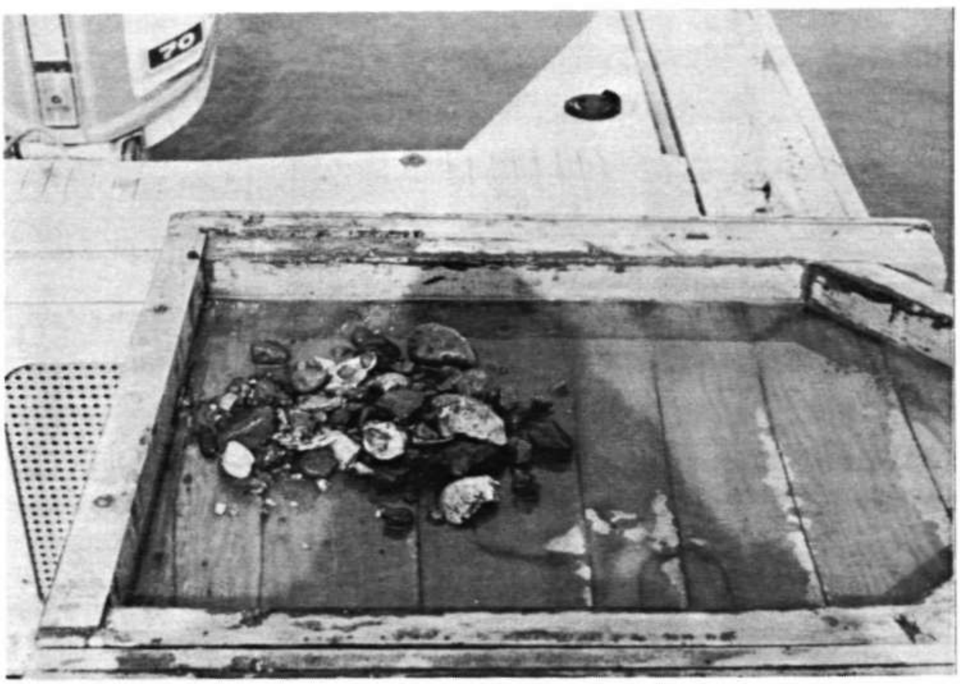
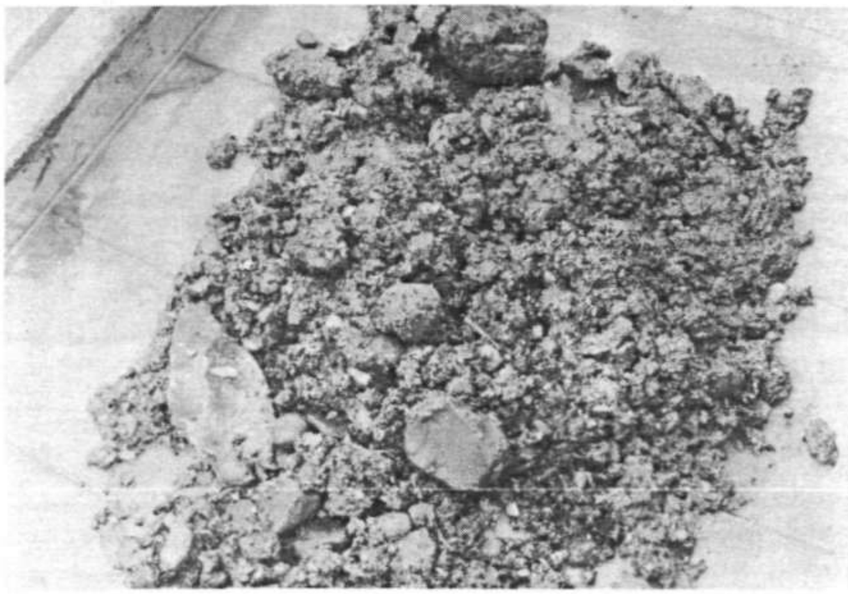


7/1,2/82

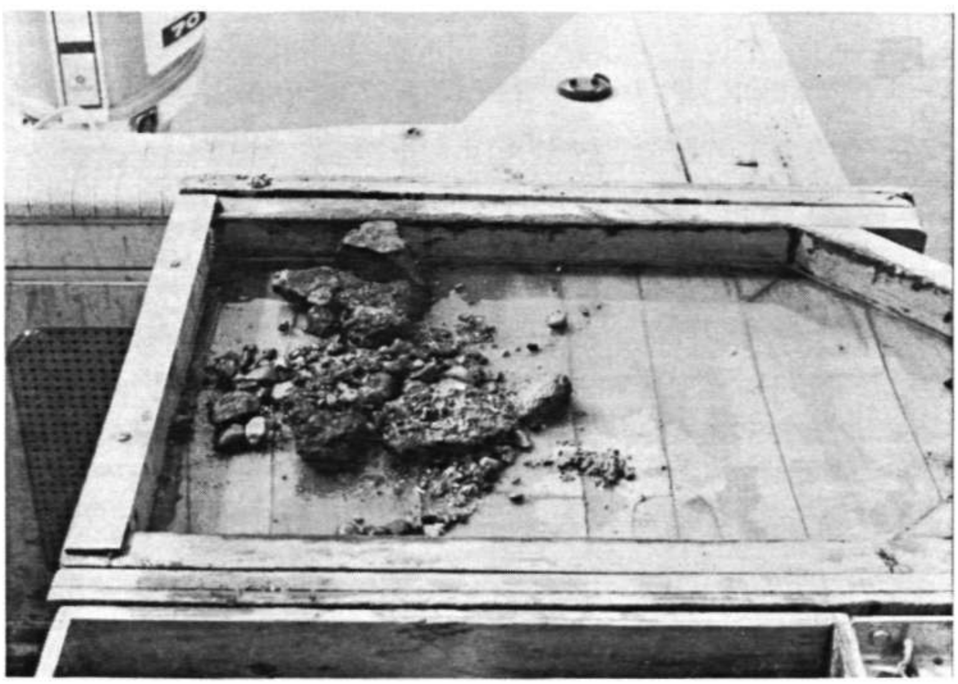


3/1/83

Station 18



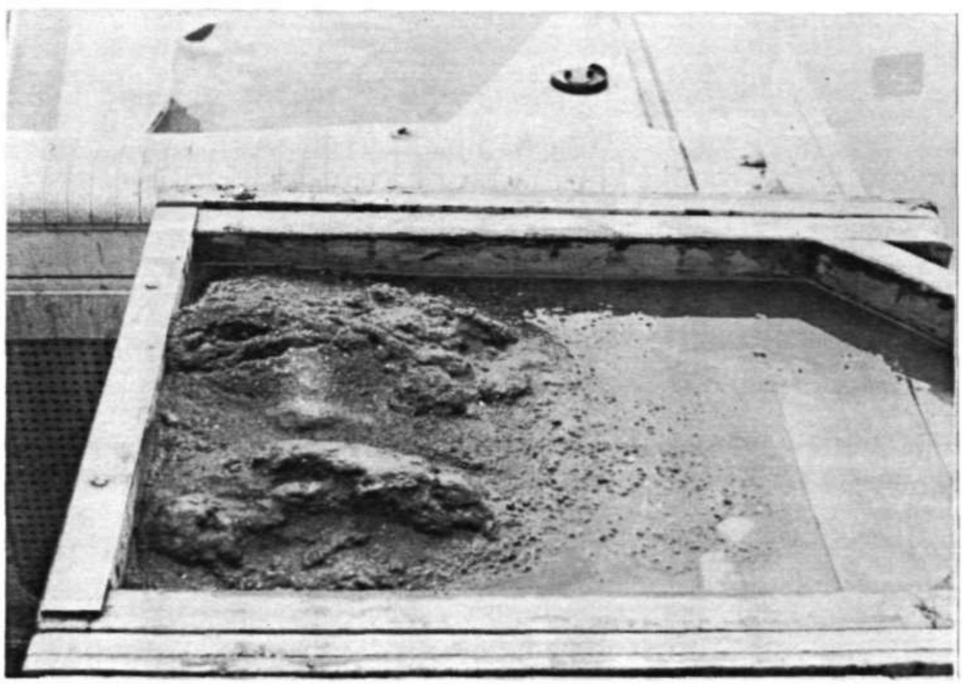
7/1,2/82



3/1/83

Station 19

7/1,2/83



3/1/83

Station 20

7/1,2/82

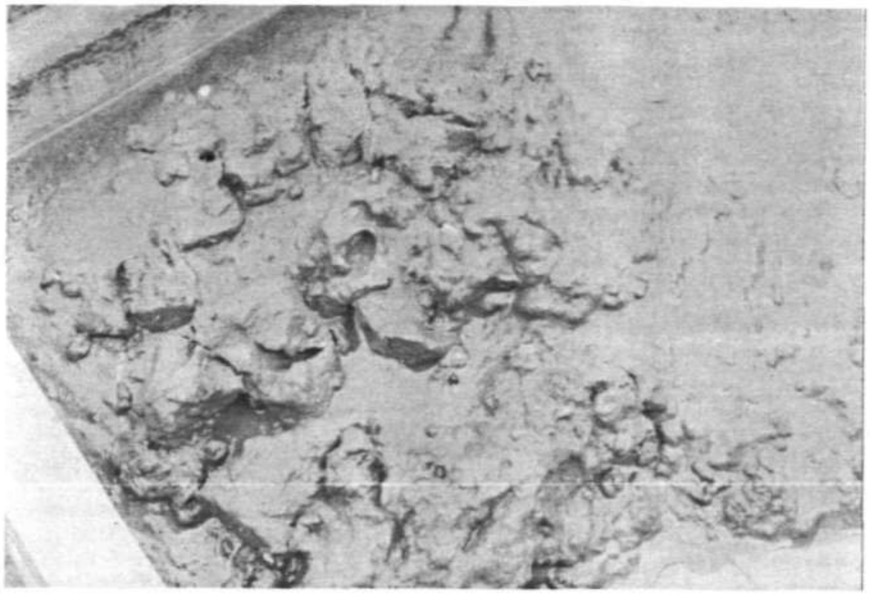
3/1/83

Station 21

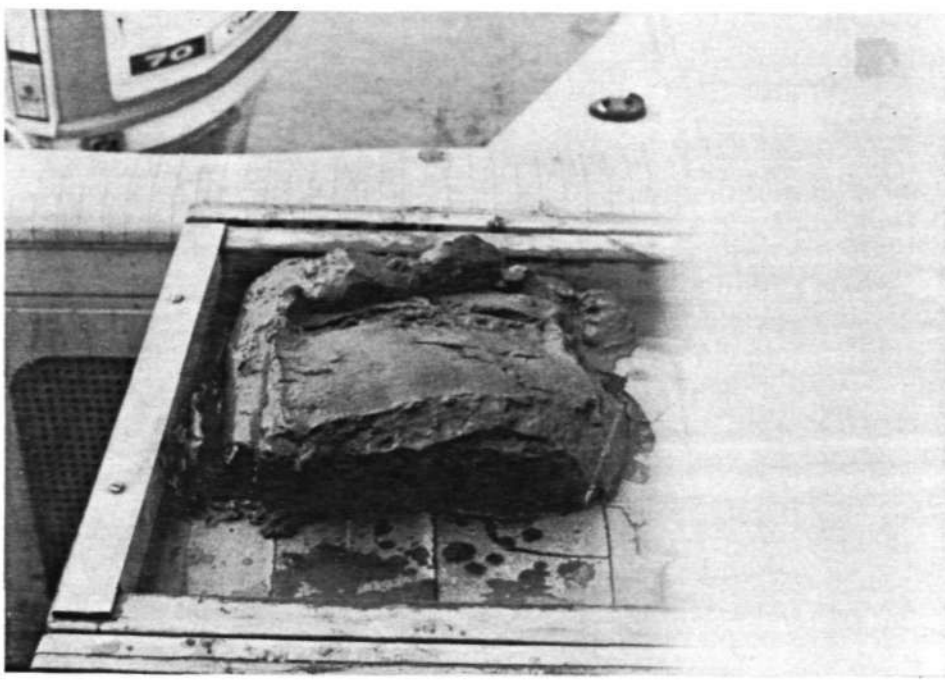
7/1,2/82

3/1/83

Station 22

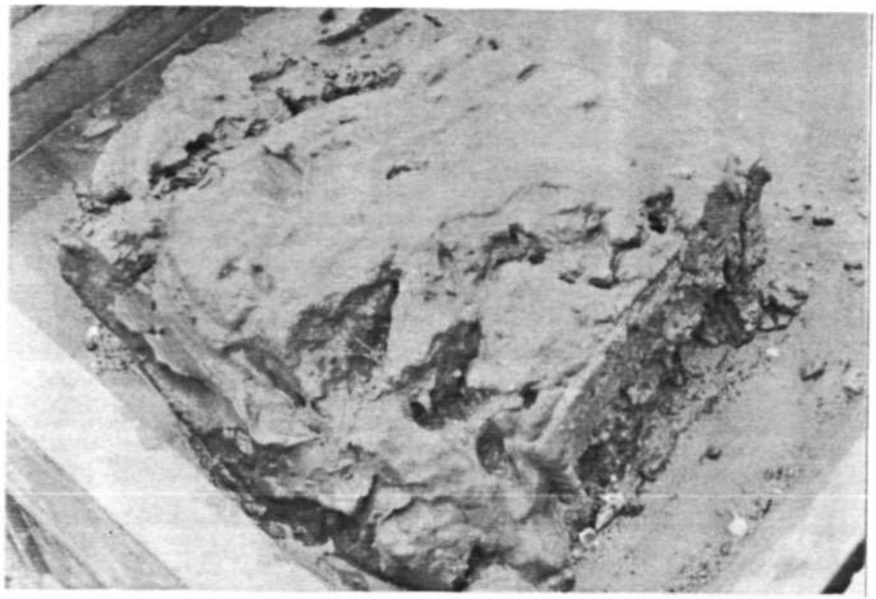


7/1,2/82



3/1/83

Station 23



7/1,2/82

Negative over exposed

3/1/83

Station 24

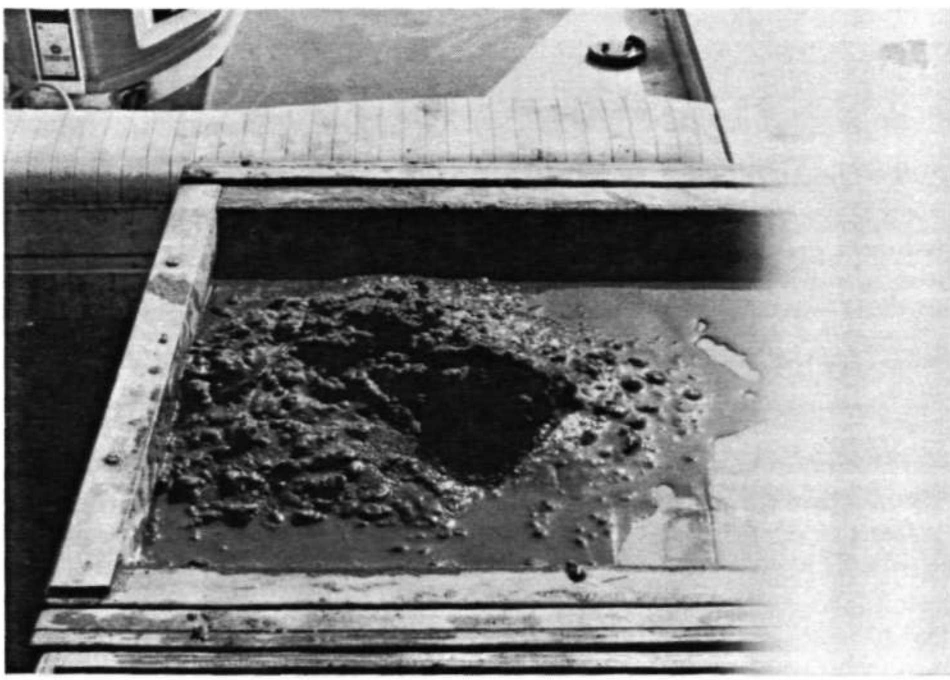
7/1,2/82

Negative over exposed

3/1/83

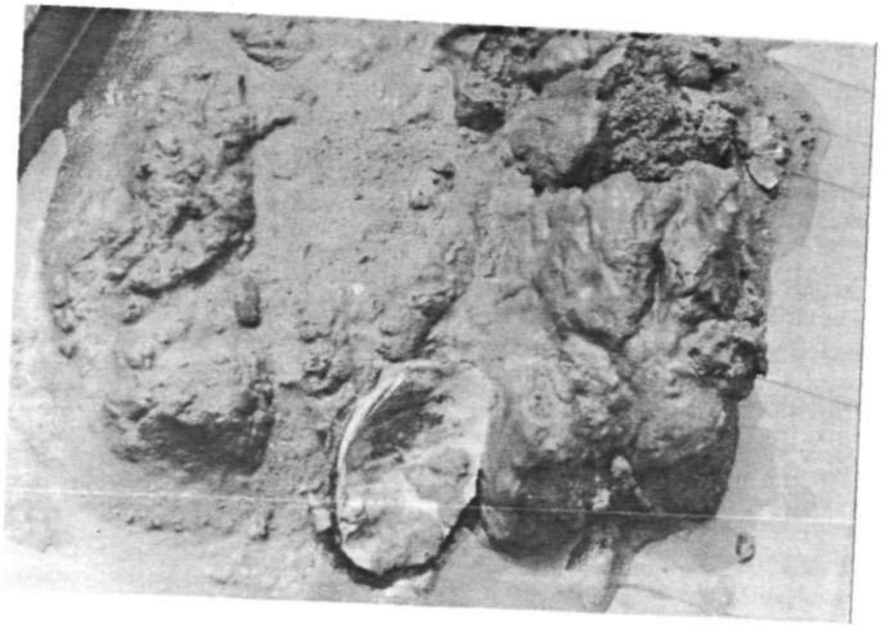
Station 25

7/1,2/82



3/1/83

Station 26

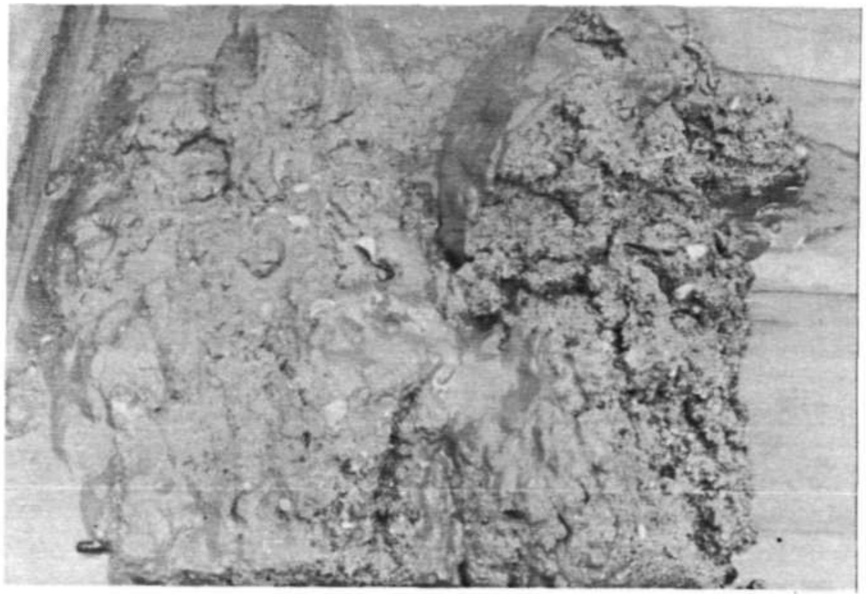


7/1,2/82

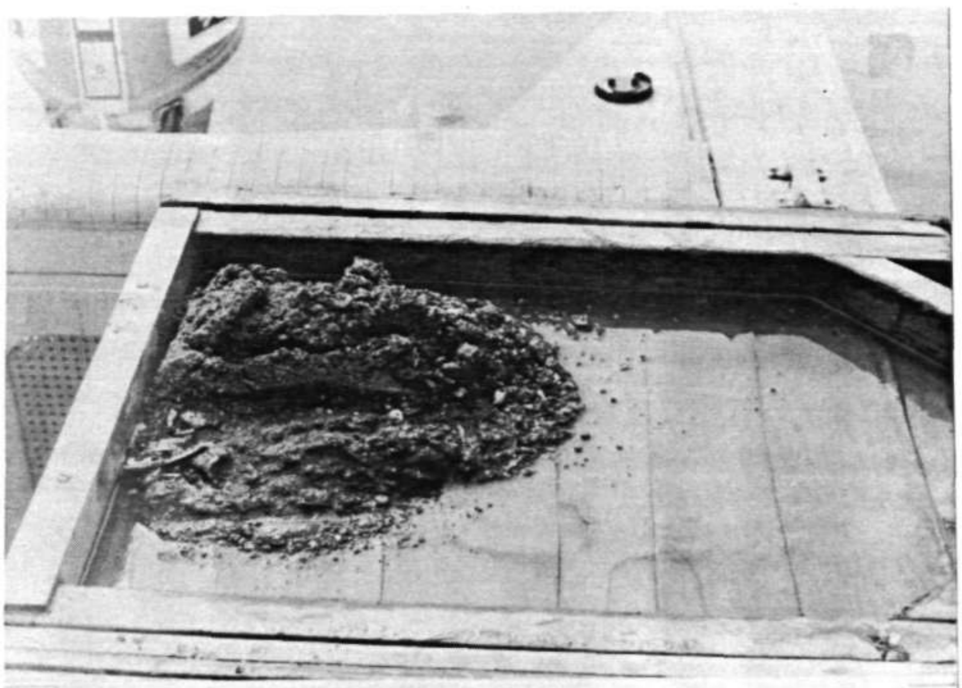
Negative over exposed

3/1/83

Station 27



7/1,2/82



3/1/83

Station 28

Appendix C

Benthic Macroinvertebrate Abundance

Appendix C
Benthic Macroinvertebrate Abundance (number/m^2) in Illinois River
Sediments at Peoria During October 1982

IEPA organism classification	Sediment Stations	1	2	3	4	5	7	8	10	16	19	20	21	'22	23	24	25	26	27	28
	Benthos Stations Taxa	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Intolerant	Unionidae (clam)								6											
Moderate	Cheumatopsyche (caddisfly)																6			
	Sphaerium (fingernail clam)		6																	
Facultative	Caenis (mayfly)									6										
	Hexagenia limbata (burrowing mayfly)	64	32	6		6	6	6								19				
	Lymnaea (snail)										6									
	Stenelmis (riffle beetle)										57				6					
Tolerant	Branchiura sowerbyl (aquatic worms)												19		26					
	Chaoborus (phantom midge)	6	38	6	96				6				6	6	19					
	Chironomidae (midge)	689	440	262	26	51	281	102	108	293	38	108	364	619	625	1,709	121	19	108	83
	Gomphus (dragonfly)													6						
	Hirudinea (leech)							13			70		26							6
	Tubificidae (sludgeworm)	6	51	13	344	51	153	38	746	753	89	185	695	1,001	2,118	408	57	38	172	140
Total number of	indlviduals/m^2	765	567	287	466	108	440	159	866	1,052	260	293	1,110	1,632	2,794	2,136	184	57	280	229
Total number of taxa		4	5	4	3	3	3	4	4	3	5	2	5	4	5	3	3	2	2	3

Appendix D

Overflow and Rainfall Data

Appendix D
Summary of Total Overflow Volume and Rainfall

Date	Sprg	Eaton	1-74	Fay	Main	Oak	Cedl	South	Darst	RN1	RN2	RN3
6/9/82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.17	0.18
6/15/82	0.04	0.04	0.01	0.01	0.05	0.02	0.00	0.03	0.68	0.59	0.72	0.53
6/22/82	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.19	0.16
6/25/82	0.02	0.02	0.00	0.00	0.03	0.02	0.02	0.03	0.05	0.32	0.19	0.22
6/27/82	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.05	0.03	0.27
6/28/82	0.42	0.14	0.02	0.15	0.09	0.09	0.42	0.10	0.11	2.25	0.29	0.93
6/29/82	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.06	0.17	0.12	0.16
7/2/82	0.33	0.58	0.15	0.58	0.37	0.04	1.86	0.71	0.21	2.14	0.47	3.18
7/7/82	0.19	0.15	0.01	0.10	0.07	0.13	0.45	0.14	1.17	0.98	0.77	0.90
7/10/82	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.03	0.01	0.12	0.25	0.12
7/13/82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.05
7/14/82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.08	0.01
7/16/82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
7/18/82	0.26	0.21	0.01	0.21	0.15	0.17	0.55	0.21	1.03	1.39	1.46	1.58
7/19/82	0.50	0.32	0.00	0.52	0.26	0.00	1.38	0.42	3.01	1.79	1.66	2.28
7/21/82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.02
7/22/82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.07	0.06
7/27/82	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.06	0.03	0.17
8/4/82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
8/5/82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.02
8/6/82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.13	0.21	0.02
8/7/82	0.12	0.11	0.01	0.09	0.10	0.09	0.34	0.12	0.86	0.89	0.83	0.90
8/10/82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.05
8/20/82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.07	0.11
8/22/82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.06	0.03
8/24/82	0.47	0.39	0.04	0.37	0.28	0.38	1.22	0.46	3.62	2.l5	2.18	1.92
8/30/82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.12	0.18
8/31/82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.07	0.05
9/1/82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.13	0.05
9/2/82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02
9/6/82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.27	0.28	0.30
9/14/82	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.11	0.14	0.15
9/17/82	0.03	0.03	0.00	0.05	0.05	0.04	0.09	0.07	0.27	0.67	0.62	0.63
9/23/82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.03
10/6/82	0.16	0.12	0.02	0.08	0.12	0.07	0.19	0.10	0.00	0.75	0.00	0.74
10/9/82	0.02	0.01	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.44	0.23	0.20
10/19/82	0.06	0.03	0.01	0.04	0.05	0.13	0.00	0.07	0.35	0.76	0.71	0.91
10/28/82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.05	0.04
11/1/82	0.22	0.21	0.04	0.17	0.04	0.23	0.72	0.23	1.63	1.72	1.49	1.52
11/11/82	0.17	0.11	0.01	0.08	0.15	0.12	0.35	0.16	0.92	1.26	1.28	1.42
11/12/82	0.08	0.04	0.01	0.05	0.05	0.07	0.09	0.08	0.41	0.74	0.58	0.74
11/18/82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02
11/19/82	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.13	0.12	0.12
11/22/82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.17	0.18	0.19
11/23/82	0.02	0.00	0.00	0.00	0.01	0.01	0.00	0.02	0.06	0.38	0.34	0.33
11/28/82	0.15	0.07	0.02	0.11	0.07	0.11	0.33	0.16	0.73	0.95	1.00	1.10
12/2/82	0.71	0.31	0.02	0.39	0.33	0.24	0.76	0.31	1.33	2.50	1.48	2.51
12/3/82	0.01	0.01	0.00	0.00	0.06	0.02	0.04	0.01	0.10	0.39	0.44	0.53
12/4/82	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.02	0.16	0.22	0.18
12/5/82	0.03	0.03	0.00	0.10	0.04	0.04	0.11	0.05	0.21	0.30	0.16	0.27

Note: Overflow volume in million cubic feet
Rainfall in inches
RN1, RN2, RN3 = Rain gages on Spring, Darst, & Fire Sta., Resp.

Appendix D

Rates of Overflow and Rainfall
June 28, 1982

Time	Sprg	Eaton	1-74	Fay	Main	Oak	Cedl	South	Darst	RN1	RN2	RN3
1400	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00
1410	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.06
1420	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00
1430	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.00	0.00	0.00
1440	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.00	0.00	0.00
1450	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.00	0.00	0.00
1500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00
1510	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	1.02
1520	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.00	0.00	2.10
1530	0.0	3.5	6.1	0.1	3.0	26.7	25.1	11.9	0.0	0.06	0.12	1.32
1540	1.0	7.7	5.0	0.1	23.3	29.0	170.6	68.2	0.0	4.32	1.26	0.00
1550	77.4	22.3	9.6	0.2	27.0	26.1	231.9	59.1	36.4	5.46	0.30	0.00
1600	189.3	22.6	2.3	0.1	8.7	9.4	147.9	19.6	85.1	1.98	0.06	0.00
1610.	173.1	72.9	4.1	5.7	16.1	4.5	54.3	5.6	37.5	1.20	0.00	0.66
1620	137.4	72.0	4.3	86.4	38.7	7.6	16.2	1.8	16.4	0.36	0.00	0.30
1630	70.6	30.4	1.0	75.9	25.6	9.9	19.9	1.3	7.7	0.06	0.00	0.06
1640	27.8	7.6	0.2	47.6	8.2	8.3	17.6	2.2	3.2	0.00	0.00	0.06
1650	9.5	2.1	0.1	26.8	2.9	8.4	9.6	1.1	2.0	.0.00	0.00	0.00
1700	3.2	0.1	0.1	11.7	1.2	5.9	2.6	0.2	0.9	0.00	0.00	0.00
1710	1.6	0.0	0.1	1.9	0.6	4.0	0.7	0.0	0.7	0.00	0.00	0.00
1720	0.9	0.0	0.1	0.1	0.2	2.6	0.0	0.0	0.5	0.06	0.00	0.00
1730	0.6	0.0	0.1	0.0	0.1	1.4	0.0	0.0	0.3	0.00	0.00	0.00
1740	0.2	0.0	0.1	0.0	0.1	0.8	0.0	0.0	0.2	0.00	0.00	0.00
1750	0.0	0.0	0.1	0.0	0.1	0.6	0.0	0.0	0.2	0.00	0.00	0.00
1800	0.0	0.0	0.1	0.0	0.1	0.6	0.0	0.0	0.2	0.00	0.00	0.00

Note: Flows in cfs, rainfalls in inches/hour
RN1, RN2, RN3 = Rain gages on Spring, Darst, and Fire Sta., Respectively

Appendix D

Rates of Overflow and Rainfall
August 24, 1982

Time	Sprg	Eaton	1-74	Fay	Main	Oak	Cedl	South	Darst	RN1	RN2	RN3
1200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00
1210	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00
1220	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00
1230	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.06	0.18	0.00
1240	0.1	0.1	0.6	0.1	0.3	0.3	0.0	3.1	3.6	1.32	2.64	1.56
1250	14.1	22.7	9.4	6.4	41.6	15.2	53.9	89.5	310.3	1.50	1.50	1.38
1300	51.1	77.6	5.1	25.7	60.7	22.0	133.6	95.4	455.5	0.42	0.48	0.36
1310	54.5	45.7	2.1	18.8	29.6	20.3	110.9	48.6	394.3	2.16	1.26	1.14
1320	76.9	59.5	8.7	56.9	57.0	49.0	161.3	64.6	412.1	1.86	1.56	1.68
1330	86.4	68.3	5.1	57.3	44.2	55.5	184.8	77.9	521.5	1.38	0.96	1.86
1340	101.2	65.2	8.1	61.5	50.5	72.9	255.0	94.3	561.6	1.38	1.38	0.90
1350	126.8	103.1	8.6	91.6	61.3	93.8	325.8	96.1	624.4	1.68	1.20	1.74
1400	124.8	93.5	10.1	94.2	59.6	87.4	278.7	90.5	614.9	0.90	1.68	0.78
1410	85.3	75.8	2.4	78.4	40.5	87.4	242.0	65.7	661.9	0.12	0.12	0.00
1420	35.8	24.5	0.1	51.6	12.8	53.2	158.6	22.2	599.5	0.06	0.06	0.06
1430	11.8	7.4	0.0	31.0	6.1	28.6	72.5	9.4	420.7	0.06	0.06	0.06
1440	4.4	4.5	0.0	18.3	4.5	18.8	33.2	7.8	248.7	0.00	0.00	0.00
1450	1.8	2.8	0.0	9.1	2.0	10.8	15.7	2.7	135.1	0.00	0.00	0.00
1500	0.9	1.2	0.0	4.3	1.0	5.7	7.9	1.1	43.1	0.00	0.00	0.00
1510	0.5	0.1	0.0	2.3	0.6	3.5	2.3	0.6	7.8	0.00	0.00	0.00
1520	0.2	0.1	0.0	1.6	0.3	2.0	0.3	0.0	4.6	0.00	0.00	0.00
1530	0.0	0.1	0.0	0.9	0.3	1.1	0.0	0.0	3.3	0.00	0.00	0.00
1540	0.0	0.1	0.0	0.5	0.2	0.6	0.0	0.0	1.5	0.00	0.00	0.00
1550	0.0	0.1	0.0	0.3	0.2	0.3	0.0	0.0	0.7	0.00	0.00	0.00
1600	0.0	0.1	0.0	0.1	0.2	0.0	0.0	0.0	0.3	0.00	0.00	0.00

Note: Flows in cfs, rainfalls in inches/hour
RNl, RN2, RN3 = Rain gages on Spring, Darst, and Fire S£a., respectively

Appendix D

Rates of Overflow and Rainfall
September 17, 1982

Time	Sprg	Eaton	1-74	Fay	Main	Oak	Cedl	South	Darst	RN1	RN2	RN3
1500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00
1510	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.06	0.00	0.06
1520	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.06	0.06	0.18
1530	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.18	0.12	0.06
1540	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.12	0.06	0.06
1550	0.0	0.0	0.1	0.0	1.8	0.0	0.0	0.0	0.5	0.06	0.06	0.06
1600	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.6	0.06	0.18	0.12
1610	0.0	0.0	0.1	0.1	2.0	0.1	0.0	0.5	2.1	0.54	0.72	0.24
1620	0.9	5.1	1.5	2.0	13.7	4.6	10.6	31.3	57.1	0.42	0.42	0.48
1630	2.4	13.8	1.4	6.6	14.2	4.1	19.7	27.7	79.8	0.60	0.42	0.72
1640	6.2	17.3	1.5	7.7	12.9	5.5	24.4	19.6	73.4	0.24	0.12	0.30
1650	13.8	8.4	0.6	7.5	6.8	5.9	28.3	10.4	33.2	0.18	0.06	0.18
1700	6.4	3.6	0.3	12.3	4.1	6.4	21.3	4.6	17.0	0.06	0.12	0.12
1710	3.7	1.2	0.2	8.9	2.4	5.4	10.6	2.2	11.4	0.18	0.12	0.12
1720	2.8	0.9	0.2	6.1	2.4	4.8	4.3	1.9	11.9	0.12	0.18	0.18
1730	2.6	1.1	0.2	4.9	2.8	4.1	3.4	3.1	19.4	0.18	0.18	0.12
1740	2.7	1.0	0.2	3.7	2.6	3.3	2.8	3.7	19.9	0.18	0.18	0.12
1750	2.7	1.4	0.2	3.2	4.0	3.2	3.1	5.1	26.77	0.18	0.18	0.12
1800	2.3	1.4	0.2	3.3	3.2	2.9	3.8	5.5	25.8	0.12	0.12	0.12
1810	0.7	1.0	0.2	3.2	2.7	2.7	3.5	4.0	22.9	0.06	0.12	0.18
1820	1.8	1.0	0.2	2.7	2.4	2.4	3.0	2.5	18.3	0.06	0.00	0.00
1830	1.2	0.6	0.1	2.5	1.2	2.1	2.1	1.3	9.2	0.00	0.00	0.06
1840	0.8	0.0	0.1	2.2	0.7	1.7	1.1	0.3	5.6	0.06	0.06	0.00
1850	0.4	0.0	0.0	1.6	0.2	1.3	0.3	0.1	3.6	0.00	0.00	0.00
1900	0.2	0.0	0.0	1.0	0.1	1.1	0.0	0.0	1.8	0.00	0.00	0.00
1910	0.1	0.0	0.0	0.6	0.0	0.8	0.0	0.0	0.8	0.00	0.00	0.00
1920	0.0	0.0	0.0	0.4	0.0	0.5	0.0	0.0	0.3	0.00	0.00	0.00
1930	0.0	0.0	0.0	0.3	0.0	0.3	0.0	0.0	0.2	0.12	0.00	0.00
1940	0.0	0.0	0.0	0.3	0.0	0.2	0.0	0.0	0.2	0.06	0.06	0.12
1950	0.0	0.0	0.1	0.4	0.8	0.1	0.0	0.0	0.2	0.06	0.00	0.00
2000	0.1	0.0	0.1	0.5	1.2	0.1	0.0	0.0	0.2	0.00	0.06	0.06
2010	0.1	0.0	0.1	0.4	0.7	0.1	0.0	0.1	0.3	0.00	0.12	0.00
2020	0.1	0.0	0.1	0.3	0.4	0.2.	0.0	0.0	1.6	0.06	0.00	0.00
2030	0.0	0.0	0.1	0.2	0.1	0.2	0.0	0.0	2.3	0.00	0.00	0.00

Note; Flows in cfs, rainfalls in inches/hour
RN1, RN2, RN3 = Rain gages on Spring, Darst, and Fire Sta., respectively

Appendix E

Results of Analyses
Performed on Combined Sewer Overflows,
June 28, August 24, and September 17, 1982

Appendix E
Results of Analyses Performed on Combined Sewer Overflows at Peoria
June 28, 1982

Sewer	Flow (Cfs)	Time interval (min)	pH	Set. BOD (mg/l)	NH_3 (mg/l)	TSS (mg/l)	Vol solids (mg/l)	Set solids (%)	Cd (mg/l)	Cu (mg/l)	Pb (mg/l)	Zn (mg/l)	Fecal coliform (#/100 mls)	Notes	
Spring St.	94.39	72	6.97	230	0.82	1310	33	4.84	<0.012	0.39	2.4	1.6	1,590,000	comp	*
	2.24	13	7.31	130	1.4	172	5.0	31.1	<0.012	0.088	0.16	0.22	1,240,000	man	
	0.97	13	7.45	98	2.6	206	4.0	34.3	<0.012	0.068	0.10	0.19	1,590,000	man	
	0.63	10	7.59	150	3.2	204	3.9	37.7	<0.012	0.071	0.14	0.16	1,510,000	man	
	0.24	10	7.63	170	3.1	152	2.8	35.9	<0.012	0.065	0.050	0.12	2,150,000	man	
	0.02	10	7.78	160	2.5	120	1.6	49.5	<0.012	0.047	0.031	0.082	2,270,000	man	
	0.0	10	7.70	280	3.0	83.7	2.2	50.7	0.018	0.052	0.026	0.082	3,040,000	man	*
	0.0	10	7.68	310	3.0	70.7	1.9	50.2	<0.012	0.045	0.028	0.10	2,000,000	man	*
	0.0	10	7.54	270	3.2	138	1.8	49.6	<0.012	0.060	0.036	0.25	1,250,000	man	*
Eaton St.	3.0	0	6.92	39	1.0	446	3.0	16.5	0.012	0.072	0.39	0.33	1,510,000	auto	
	10.62	10	7.08	18	0.56	708	4.5	8.18	<0.012	0.12	0.72	0.47	710,000	auto	
	22.3	8	7.05	28	0.36	575	4.7	4.45	<0.012	0.082	0.50	0.34	310,000	auto	
	22.6	10	6.95	55	0.47	1160	9.0	12.6	<0.0l2	0.16	0.75	0.58	1,245,000	auto	
	72.9	10	6.92	19	0.48	788	10	5.61	<0.012	0.091	0.49	0.40	760,000	auto	
	72.0	10	7.15	11	0.20	420	8.1	2.83	<0.012	0.080	0.28	0.22	176,000	auto	
	—	—	7.44	18	0.98	372	2.3	18.4	<0.012	0.070	0.23	0.19	885,000	comp 7,8,9?	*
1-74	5.77	—	7.95	14	0.21	1380	32	4.71	<0.012	0.14	2.1	1.4	520,000	auto	
	8.14	—	7.49	12	0.11	2190	Insufficient sample volume		<0.012	0.31	4.7	2.6	43,000	low volume	
Fayette St.	42.60	51	6.77	170	1.1	3550	27	18.6	<0.012	0.43	1.2	1.4	1,660,000	comp	*
Main St.	15.23	100	7.57	36	0.99	690	7.0	17.1	<0.012	0.20	0.71	0.62	930,000	comp	*
Oak St.	26.93	0	8.23	9.6	0.14	934	2.6	11.4	0.012	0.16	0.59	0.52	70,000	auto	
	28.71	10	8.18	8.7	0.11	840	3.4	6.73	<0.012	0.17	0.45	0.46	100,000	auto	
	24.43	10	7.17	12	1.3	618	2.9	5.60	<0.012	0.086	0.31	0.36	680,000	auto	
	8.91	10	7.53	16	2.4	543	1.8	15.6	<0.012	0.078	0.28	0.29	1,000,000	auto	
	4.81	10	7.45	17	0.56	460	2.7	9.10	<0.012	0.11	0.38	0.30	580,000	auto	
	7.83	10	7.73	9.7	0.36	426	2.0	12.6	<0.012	0.16	0.38	0.32	103,000	auto	
	9.74	lo	7.77	8.8	0.21	559	2.1	8.86	<0.0l2	0.080	0.25	0.36	140,000	auto	
	8.31	10	7.44	20	1.3	605	3.2	13.8	<0.012	0.092	0.54	0.32	450,000	auto	
	8.15	10	7.27	61	0.90	1130	7.0	14.4	<0.012	0.16	0.75	0.66	445,000	auto	
	5.71	10	7.46	40	0.78	822	4.5	15.7	<0.012	0.12	0.49	0.44	450,000	auto	
	3.76	10	7.15	23	0.43	781	6.5	17.7	<0.012	0.16	0.46	0.45	320,000	auto	
	2.84	10	7.23	13	0.42	479	3.4	17.6	<0.012	0;12	0.29	0.28	182,000	auto	

* = sample not used in analysis of data

Appendix E
Results of Analyses Performed on Combined Sewer Overflows at Peoria
June 28, 1982 (Cont'd.)

Sewer	Flow (cfs)	Time interval (min)	pH	BOD_5 (mg/l)	NH_3 (mg/l)	TSS (mg/l)	Set solids (mg/l)	Vol set solids (%)	Cd (mq/l)	Cu (mg/l)	Pb (mg/l)	Zn (mg/l)	Fecal coliform (#100/mls)	Notes
Cedar St.	17.6	0	6.96	30	0.92	499	4.8	24.2	0.012	0.093	0.28	0.30	1,500,000	man
	9.6	10	6.96	25	0.80	333	3.5	23.2	<0.012	0.074	0.22	0.22	1,280,000	man
	2.6	10	7.03	62	0.78	304	3.6	32.5	<0.012	0.074	0.19	0.21	1,160,000	man
	0.7	10	7.22	44	1.2	220	3.7	34.2	<0.012	0.064	0.16	0.18	960,000	man
	0.2	10	7.29	47	1.3	210	3.6	37.0	<0.012	0.050	0.14	0.18	3,360,000	man *
	0.0	10	7.34	60	1.7	181	1.8	41.4	<0.012	0.070	0.061	0.16	4,060,000	man *
	0.0	10	7.45	160	2.2	163	3.6	49.1	<0.012	0.050	0.040	0.11	3,000,000	man *
	0.0	10	7.45	54	2.3	140	3.2	50.2	<0.012	0.055	0.026	0.010	4.000,000	man *
South St.	8.33	0	8.12	110	1.5	498	6.6	21.8	<0.012	0.14	0.42	0.42	2,470,000	auto
	52.71	10	7.67	41	0.23	1170	6.8	17.4	<0.012	0.37	1.0	1.2	335,000	auto
	61.83	10	7.59	40	0.13	559	3.1	16.5	<0.012	0.20	0.56	0.56	213,000	auto
	31.45	10	7.41	16	0.23	299	2.4	9.80	<0.012	0.14	0.40	0.37	300,000	auto
	9.8	10	7.31	19	0.32	238	1.6	19.8	<0.012	0.12	0.40	0.31	292,000	auto
Darst St.	46.14	0	6.70	300	1.9	874	7.5	29.4	<0.012	0.13	0.35	0.50	3,040,000	auto
	75.58	10	6.83	40	0.68	1360	6.6	24.6	<0.012	0.11	0.46	0.44	1,830,000	auto
	33.28	10	6.86	34	0.78	701	5.4	25.1	<0.012	0.082	0.25	0.33	2,000,000	auto
	14.66	10	6.89	58	1.4	492	4.4	21.8	<0.012	0.080	0.25	0.28	3,010,000	auto
	6.8	10	7.04	53	1.7	423	4.3	26.5	<0.012	0.080	0.20	0.26	2,475,000	auto

* = sample not used in analysis of data

Appendix *E*
Results of Analyses Performed on Combined Sewer Overflows at Peoria
August 24, 1982

Sewer	Flow (cfs)	Time Interval (min)	pH	BOD_5 (mg/l)	NH_3 (mg/l)	TSS (mg/l)	Set solids (mg/l)	Vol set solids (%)	Cd (mg/l)	Cu (mg/l)	Pb (mg/l)	Zn (mg/l)	Fecal coliform (#/100 mls)	Notes
Spring St.	14.1	0	6.76	170	1.5	886	18.5	18.0	<0.012	0.16	0.76	0.48	3,970,000	auto
	51.1	10	6.71	65	<0.1	644	7.4	13.6	<0.012	0.11	0.34	0.33	2,380,000	auto
	54.1	10	6.56	60	<0.1	501	5.6	12.0	<0.012	0.060	0.18	0.20	2,590,000	auto
	76.9	10	6.63	31	<0.1	390	3.7	10.6	<0.012	0.060	0.26	0.18	990,000	auto
	86.4	10	6.65	15	<0.1	268	2.4	9.66	<0.012	0.032	0.20	0.12	740,000	auto
	101.2	10	6.69	14	<0.1	278	2.9	5.37	<0.012	0.030	0.10	0.089	535,000	auto
	103.76	7	6.73	13	<0.1	302	2.8	5.24	<0.012	0.025	0.12	0.092	265,000	auto
	126.6	10	6.71	7.1	<0.1	270	2.0	5.46	<0.012	0.032	0.12	0.10	570,000	auto
	120.75	10	6.76	12	<0.1	242	2.3	5.21	<0.012	0.036	0.14	0.10	630,000	auto
	80.35	10	6.72	13	<0.1	172	1.6	9.94	<0.012	0.032	0.066	0.080	760,000	auto
	33.4	10	6.67	74	<0.1	277	2.8	11.9	<0.012	0.050	0.14	0.11	1,340,000	auto
	11.06	10	6.84	62	<0.1	222	2.4	16.5	<0.012	0.052	0.10	0.12	1,860,000	auto
	1.62	20	6.92	37	<0.1	223	1.9	28.3	<0.012	0.065	0.055	0.13	2,560,000	auto
Eaton St.	29.63	0	6.91	20	0.26	552	6.9	2.36	<0.012	0.038	0.14	0.13	620,000	auto
	9.11	10	7.10	36	1.2	216	3.7	12.5	<0.012	0.062	0.060	0.14	840,000	auto
	4.79	10	7.13	26	1.4	152	2.2	21.7	<0.012	0.084	0.044	0.095	630,000	auto
	2.97	10	7.05	32	1.4	137	2.1	35.5	<0.012	0.053	0.043	0.072	1,200,000	auto
	1.36	10	7.35	44	1.0	79.4	1.9	52.6	<0.012	0.048	0.024	0.060	13,000	auto
1-74	7.64	0	6.98	15	<0.1	416	2.1	23.6	<0.012	0.045	0.44	0.48	53,500	auto
	5.96	10	7.14	8.0	<0.1	426	5.6	11.5	<0.012	0.042	0.42	0.36	37,000	auto
	2.7	10	8.00	5.5	<0.1	514	11	2.26	<0.012	0.060	0.54	0.40	47,000	auto
	7.38	10	7.58	3.8	0.19	71.9	1.2	3.97	<0.012	0.032	0.14	0.14	42,000	auto
	8.69	42	7.41	4.9	<0.1	256	5.3	3.66	<0.012	0.032	0.32	0.25	20,000	comp *
	4.71	7	6.89	3.9	<0.1	275	0.4	22.4	<0.012	0.035	0.34	0.26	34,000	auto

* = sample not used in analysis of data

Appendix E
Results of Analyses Performed on Combined Sewer Overflows at Peoria
August 24, 1982 (Cont'd.)

5ewer	Flow (Cfs)	Time interval (min)	pH	BOD_5 (mg/l)	NH_3 fag/l)	TSS (mg/l)	Set solids (mg/l)	Vol set solids (%)	Cd (mg/l)	Cu (mg/l)	Pb (mg/l)	Zn (mg/l)	Fecal coliform (#/100 mis)	Notes	
Fayette St.	8.33	0	6.83	67	2.5	453	6.1	27.2	<0.012	0.12	0.38	0.36	1,770,000	auto	
	25.01	10	6.96	23	0.56	410	3.6	13.9	<0.012	0.052	0.28	0.20	825,000	auto	
	22.61	10	7.06	180	5.8	391	7.4	23.2	<0.012	0.10	0.11	0.33	900,000	auto	
	56.94	10	6.88	73	0.66	520	6.7	17.9	<0.012	0.10	0.19	0.24	840,000	auto	
	57.72	10	6.76	70	0.41	386	7.3	20.7	<0.012	0.075	0.11	0.20	1,020,000	auto	
	64.51	10	6.79	29	0.33	221	2.5	14.7	<0.012	0.050	0.16	0.11	790,000	auto	
	91.86	10	6.78	34	0.20	273	2.7	13.4	<0.012	0.055	0.38	0.13	1,340,000	auto	
	92.62	10	6.84	28	0.12	236	2.6	8.23	<0.012	0.045	0.14	0.12	520,000	auto	
	75.72	10	6.83	28	0.32	210	3.5	8.03	<0.012	0.068	0.15	0.12	550,000	auto	
	49.54	10	6.88	26	0.42	288	4.5	6.51	<0.012	0.056	0.060	0.095	755,000	auto	
	6.78	60	6.86	65	1.8	518	4.9	7.40	<0.012	0.10	0.14	0.22	1,420,000	comp	*
Main St.	33.34	0	6.85	26	0.23	406	3.7	9.23	<0.012	0.12	0.48	0.35	380,000	auto	
	46.76	40	6.90	7.3	<0.1	124	1.5	3.82	<0.012	0.052	0.11	0.098	94,000	auto	
	49.24	10	6.86	2.7	<0.1	94.5	1.1	2.16	<0.012	0.035	0.095	0.058	128,000	auto	
	59.14	10	6.94	4.8	<0.1	130	1.7	2.04	<0.012	0.042	0.14	0.085	75,000	auto	
	60.94	10	6.95	5.4	<0.1	123	1.3	2.86	<0.012	0.030	0.14	0.068	54,0000	auto	
	44.32	10	7.20	11	<0.1	96.5	1.1	2.61	<0.012	0.040	0.088	0.068	230,000	auto	
	18.34	10	6.94	21	<0.1	126	1.3	3.60	<0.012	0.052	0.15	0.14	3,000,000	auto	
	7.44	10	7.16	30	<0.1	80.4	1.4	3.06	<0.012	0.048	0.14	0.11	2,040,000	auto	
	4.82	10	7.36	48	<0.1	96.2	1.7	10.4	<0.012	0.048	0.064	0.095	830,000	auto	
	1.2	20	6.93	150	0.32	121	4.8	17.2	<0.012	0.16	0.027	0.20	920,000	auto	
Oak St.	15.2	0	7.48	19	<0.1	575	3.3	8.77	<0.012	0.30	0.55	0.51	110,000	auto'	
	49.43	50	7.42	22	0.92	709	3.6	6.19	<0.012	0.12	0.40	0.33	200,000	comp	*
	77.08	2	7.46	9.5	0.14	934	4.9	3.20	<0.012	0.088	0.35	0.32	205,000	man	
	32.70	92	7.43	9.6	0.22	1710	20	1.08	<0.012	0.10	0.49	0.47	140,000	comp	*
Cedar St.	5.39	0	7.06	160	3.6	715	7.9	29.6	<0.012	0.18	0.68	0.64	2,625,000	auto	
	131.33	20	6.15	140	1.0	831	8.0	29.4	<0.012	0.18	0.58	0.51	1,780,000	auto	
	115.94	10	6.94	64	<0.1	476	3.0	25.5	<0.012	0.13	0.30	0.38	1,480,000	auto	
	120.98	1	6.81	46	<0.1	402	4.4	23.3	<0.012	0.088	0.24	0.28	1,600,000	auto	
	106.0	10	6.80	40	<0.1	325	3.6	17.3	<0.012	0.082	0.22	0.24	1,020,000	auto	
	316.38	30	6.94	13	<0.1	281	2.5	7.24	<0.012	0.062	0.14	0.20	540,000	auto	

* = sample not used in analysis of data

Appendix K
Results of Analyses Performed on Combined Sewer Overflows at Peoria
August 24, 1982 (Conc'd.)

Sewer	Flow (cfs)	Time interval (min)	pH	BOD_5 (mg/l)	NH_3 (mg/l)	TSS (mg/l)	Set solids (mg/l)	Vol set solids (%)	Cd (mg/l)	Cu (mg/l)	Pb (mg/l)	Zn (mg/l)	Fecal coliform (#/100 mls)	Notes
South St.	63.58	0	6.94	150	<0.1	910	8.7	21.4	<0.012	0.40	1.1	0.84	2,730,000	auto
	93.63	10	7.00	96	<0.1	510	2.8	17.9	<0.012	0.31	0.75	0.63	1,500,000	auto
	62.64	10	6.94	30	<0.1	312	2.7	9.59	<0.012	0.24	0.42	0.32	2,500,000	auto
	59.8	10	6.96	15	<0.1	300	1.9	11.6	<0.012	0.12	0.38	0.26	1,100,000	auto
	73.91	10	7.08	14	<0.1	324	2.0	12.2	<0.012	0.12	0.24	0.26	130,000	auto
	89.38	10	7.05	9.2	<0.1	213	1.3	13.5	<0.012	0192	0.18	0.26	43,500	auto
	95.74	11	7.11	11	<0.1	200	1.8	7.66	<0.012	0.16	0.28	0.32	27,000	auto
	91.62	10	7.15	12	<0.1	162	1.0	11.2	<0.012	0.098	0.25	0.24	19,000	auto
	70.66	10	6.90	12	<0.1	186	1.7	8.25	<0.012	0.13	0.22	0.27	56,000	auto
	30.9	10	6.86	19	<0.1	128	1.5	8.35	<0.012	0.11	0.26	0.28	26,000	auto
	8.38	20	6.87	31	<0.1	185	2.2	8.01	<0.012	0.11	0.25	0.29	400,000	corr.p *
Darst St.	279.63	0	6.79	170	1.0	1440	9.4	18.0	<0.012	0.20	0.65	0.97	2,635,000	auto
	440.98	10	6.72	250	1.6	963	13	29.6	<0.012	0.50	0.44	0.68	1,800,000	auto
	400.42	10	6.79	300	2.7	1010	12	25.4	<0.012	0.38	0.40	0.78	1,520,000	auto
	410.32	10	6.69	47	0.49	401	3.5	16.3	<0.012	0.078	0.22	0.25	710,000	auto
	510.32	10	6.74	39	0.33	405	4.2	13.2	<0.012	0.098	0.22	0.26	840,000	auto
	557.59	10	6.60	16	0.34	293	2.5	13.0	<0.012	0.058	0.20	0.16	660,000	auto
	561.6	7	6.65	16	0.28	330	2.6	13.9	<0.012	0.055	0.16	0.14	450,000	auto
	624.4	10	6.74	22	0.33	300	2.9	13.6	<0.012	0.048	0.14	0.14	560,000	auto
	614.9	10	6.77	19	0.20	344	3.4	9.52	<0.012	0.055	0.15	0.19	690,000	auto
	661.9	10	6.67	27	0.13	403	4.0	16.0	<0.012	0.060	0.18	0.19	890,000	auto
	599.5	10	6.67	39	0.16	412	3.8	18.1	<0.012	0.10	0.15	0.19	1,350,000	auto
	420.7	10	6.73	44	0.36	524	5.2	21.6	<0.012	0.092	0.15	0.20	1,260,000	auto
	386.3	2	6.76	46	0.42	382	4.9	23.7	<0.012	0.088	0.16	0.21	1,510,000	auto
	12.69	60	6.84	45	1.0	493	5.3	11.6	<0.012	0.13	0.12	0.23	1,680,000	comp *

* = sample not used in analysis of data

Appendix E
Results of Analyses Performed on Combined Sewer Overflows at Peoria
September 17, 1982

Sewer	Flow (cfs)	Time interval (min)	pH	B0D5 (mg/l)	NH3 (mg/l)	TSS (mg/l)	Set solids (mg/l)	Vol set solids (%)	Cd (mg/l)	Cu (mg/l)	Pb (mg/l)	Zn (mg/l)	Fecal coliform (#/100 mis)	Notes
Spring St.	1.2	0	6.95	340	2.2	998	19	36.9	<0.012	0.38	1.0	1.0	5,000	auto
	2.4	8	6.89	100	0.76	543	4.4	28.3	<0.012	0.48	0.48	0.44	5,000	auto
	6.2	10	6.82	140	0.40	667	8.6	26.5	<0.012	0.16	0.32	0.43	Plate wash out	auto
	12.28	8	6.91	100	0.64	427	5.5	31.7	<0.012	0.12	0.22	0.33	3,000	auto
	7.88	10	6.86	110	—	337	5.3	39.4	<0.012	0.14	0.075	0.26	1,000	auto
	4.24	10	8.00	51	0.88	165	2.2	38.0	<0.012	0.075	0.055	0.23	1,160,000	auto
	3.7	2	7.54	50	0.70	154	2.0	42.2	<0.012	0.099	0.10	0.18	1,170,000	auto
	2.8	10	7.19	48	1.1	120	1.6	50.0	<0.012	0.058	0.031	0.21	2,200,000	auto
	2.6	10	7.58	67	1.0	141	2.4	48.2	<0.012	0.070	0.040'	0.16	870,000	auto
	2.68	8	7.30	57	0.73	101	2.2	54.1	0.035	0.050	0.037	0.16	1,440,000	auto
	2.7	10	7.02	49	1.2	85.3	0.4	41.9	0.018	0.048	-0.041	0.092	1,160,000	auto
	2.38	10	7.24	32	1.3	73.0	0.5	32.5	<0.012	0.050	0.037	0.11	1,210,000	auto
	1.69	21	7.35	34	1.6	62.0	0.4	35.4	<0.012	0.047	0.044	0.084	1,060,000	auto
	0.84	20	7.49	44	2.1	70.5	0.9	51.9	<0.012	0.045	0.030	0.095	1,520,000	auto
Eaton St,	5.97	0	6.91	280	0.68	518	6.3	23.3	<0.012	0.22	0.53	0.50	1,735,000	auto
	14.15	10	6.91	64	0.54	291	2.3	15.6	<0.012	0.12	0.26.	0.26	725,000	auto
	16.41	10	6.86	38	0.48	289	3.9	18.6	<0.012	0.092	0.14	0.24	Plate wash out	auto
	7.92	10	7.02	21	0.54	136	0.8	16.6	<0.012	0.072	0.078	0.16	1,290,000	auto
	3.36	10	7.10	25	0.64	96.0	0.5	19.3	<0.012	0.059	0.040	0.12	1,380,000	auto
	1.17	10	7.08	37	0.75	77.1	0.4	34.7	0.075	0.092	0.038	0.11	1,480,000	auto
	0.94	11	7.6	45	0.96	80.9	0.2	30.8	<0.012	0.065	0.034	0.11	290,000	auto
	1.08	10	7.6	24	0.72	65.2	0.3	41.3	<0.012	0.058	0.031	0.092	183,000	auto
	1.08	10	7.7	15	0.68	66.2	0.1	31.6	<0.012	0.058	0.039	0.10	300,000	auto
	1.4	10	7.6	23	0.50	76.7	0.5	31.2	<0.012	0.058	0.039	0.11	360,000	auto
	1.32	10	7.55	20	0.44	65.6	0.2	39.0	<0.012	0.056	0.046	0.091	605,000	auto
	1.0	10	7.16	17	0.98	66.7	0.2	27.4	<0.012	0.048	0.035	0.098	330,000	auto
	0.42	21	7.23	34	0.62	57.8	0.3	43.8	<0.012	0.052	0.030	0.10	410,000	auto
1-74	1.46	0	7.24	22	0.23	338	1.1	22.0	<0.012	0.065	0.02	0.72	54,000	auto
	1.44	10	7.25	14	<0.1	201	0.6	23.7	<0.012	0.050	0.32	0.44	24,000	auto
	1.14	10	7.23	14	<0.1	HO	0.1	11.7	<0.012	0.050	0.27	0.32	39,500	auto

Appendix E
Results of Analyses Performed on Combined Sower Overflown at Peoria
September 17, 1982 (Cont'd.)

Sewer	(cfs)	Time interval (min)	pH	BOD_5 (mg/l)	NH_3 (mg/l)	TSS (mg/l)	Set solids (mq/l)	Vol solids (%}	Cd (mg/l)	set Cu (mg/l)	Pb (mg/l)	Zn mg/l)	Fecal coliform (#/100 mls)	Notes
Fayette St.	3.38	0	6.91	120	3.0	387	2.5	24.5	<0.012	0.14	0.46	0.11	4,300,000	auto
	6.93	10	6.88	110	1.7	314	2.2	28.5	<0.012	0.12	0.34	0.34	3,750,000	auto
	7.64	10	6.87	120	2.1	298	4.6	31.5	<0.012	0.12	0.34	0.29	2,460,000	auto
	8.94	10	6.90	480	7.4	1310	36	49.3	<0.012	0.55	0.42	1.3	3,170,000	auto
	11.28	10	6.83	240	2.4	842	12	29.7	<0.012	0.24	0.47	0.80	2,330,000	auto
	8.06	10	6.86	200	1.3	723	10	30.8	<0.0l2	0.17	0.36	0.62	1,860,000	auto
	5.74	10	7.03	100	1.3	327	6.6	25.5	<0.012	0.12	0.11	0.31	1,320,000	auto
	4.54	10	7.10	70	1.4	230	4.4	28.9	<0.012	0.085	0.076	0.23	2,540,000	auto
	3.55	10	7.21	48	1.9	142	2.2	24.2	<0.012	0.045	0.0G0	0.17	2,080,000	auto
	3.23	10	7.02	72	1.5	157	2.7	30.4	<0.012	0.075	0.064	0.18	1,680,000	auto
	3.27	10	6.77	170	1.5	358	7.8	46.6	<0.012	0.15	0.0S2	0.36	1,650,000	auto
	3.05	10	7.01	86	2.1	192	1.1	31.2	<0.012	0.082	0.040	0.18	730,000	auto
	2.41	20	7.06	71	2.0	190	3.1	33.1	0.16	0.062	0.030	0.12	1,220,000	auto
	1.42	20	7.24	58	3.0	238	2.4	16.8	<0.012	0.036	0.036	0.12	995,000	auto
Main St.	1.35	0	7.05	160	3.0	374	7.1	34.4	<0.012	0.44	0.44	0.51	850,000	auto
	1.6	10	7.07	120	4.1	228	7.4	39.4	<0.012	0.26	0.26	0.30	1,720,000	auto
	1.7	10	7.12	50	4.2	99	1.4	37.0	<0.012	0.26	0.26	0.20	2,200,000	auto
	7.85	10	7.14	68	1.5	476	4.7	21.9	<0.012	0.69	0.69	0.82	1,040,000	auto
	13.95	10	7.10	44	1.0	266	1.6	16.0	<0.012	0.36	0.36	0.32	840,000	auto
	13.55	10	7.21	23	0.68	156	1.9	11.9	<0.012	0.26	0.26	0.20	215,000	auto
	9.85	10	7.7	16	0.44	91.2	0.6	11.5	<0.012	0.060	0.060	0.11	840,000	auto
	5.45	10	7.7	18	0.50	72.6	0.4	11.8	<0.012	0.059	0.059	0.14	880,000	auto
	3.25	10	7.7	6.2	0.68	56.3	0.7	28.1	<0.012	0.049	0.049	0.14	1,060,000	auto
	2.4	10	7.7	22	0.86	51.6	0.4	33.2	<0.012	0.041	0.041	0.10	3,700,000	auto
	2.6	10	7.7	18	0.41	53.8	0.2.	32.2	<0.012	0.050	0.050	0.13	680,000	auto
	3.3	20	7.7	13	0.34	70.2	0.1	27.4	<0.012	0.062	0.062	0.13	280,000	auto
	2.95	20	7.7	17	0.44	46.6	0.1	32.9	<0.012	0.042	0.042	0.16	345,000	auto
	1.8	20	7.7	17	0.52	34.3	<0.1	28.5	<0.012	0.046	0.046	0.080	360,000	auto

Appendix E
Results of Analyses Performed on Combined Sewer Overflows at Peoria
September 17, 1982 (Cont'd.)

Sewer	Flow (cfs)	Time interval (min)	pH	BOD_5 (mg/l)	NH_3 (mg/l)	TSS (mg/l)	Set solids (mg/l)	Vol set solids (%)	Cd (mg/l)	Cu (mg/l)	Pb (mq/l)	Zn (mg/l)	Fecal coliform (#/100 mls)	Notes
Oak St.	4.5	0	8.0	35	2.2	555	4.2	4.98	<0.012	0.22	0.42	0.48	83,000	auto
	4.38	10	7.85	52	0.84	377	3.3	8.52	<0.012	0.15	0.45	0.37	151,000	auto
	5.58	10	7.7	42	4.0	425	3.4	4.89	<0.012	0.082	0.32	0.22	570,000	auto
	6.0	10	7.5	62	3.5	298	7.0	2.94	<0.012	0.098	0.36	0.31	880,000	auto
	6.2	10	7.3	160	1.8	599	11	4.87	<0.012	0.36	0.54	0.72	1,890,000	auto
	5.28	10	7.4	100	1.1	573	5.0	10.4	<0.012	0.24	0.52	0.44	610,000	auto
	4.1	18	7.35	140	1.0	393	6.4	14.8	<0.012	0.22	0.30	0.34	850,000	auto
	3.22	18	7.7	27	0.62	205	1.8	6.22	<0.012	0.082	0.095	0.18	400,000	auto
	2.78	18	7.65	20	0.48	139	1.2	4.91	<0.012	0.070	0.082	0.15	390,000	auto
	2.28	18	7.7	14	0.56	99.1	0.6	5.36	<0.012	0.060	0.066	0.17	335,000	auto
	1.62	18	7.7	17	0.56	74.8	0.6	3.39	<0.012	0.048	0.051	0.094	114,500	auto
	1.1	18	7.7	16	0.54	60.5	0.6	4.60	<0.012	0.045	0.052	0.078	84,000	auto
	0.48	21	7.26	12	0.54	63.4	0.3	5.84	<0.012	0.040	0.045	0.13	63,500	auto
Cedar St.	16.06	0	6.76	290	3.4	1100	6.7	22.7	<0.012	0.24	0.70	0.80	1,830,000	auto
	22.52	10	6.87	210	3.1	850	11	34.4	<0.012	0.41	0.60	1.0	3,000,000	auto
	26.74	10	6.84	230	2.0	633	7.9	22.5	<0.012	0.38	0.58	0.80	2,700,000	auto
	24.1	10	6.86	170	1.4	445	6.2	16.6	<0.012	0.30	0.44	0.52	3,055,000	auto
	14.88	10	7.4	110	1.2	382	5.9	21.4	<0.012	0.20	0.36	0.40	1,580,000	auto
	6.82	10	7.4	160	1.3	355	4.1	19.9	<0.012	0.18	0.30	0.39	1,940,000	auto
	3.76	10	7.4	120	1.5	278	3.8	26.4	<0.012	0.15	0.11	0.32	plate wash out	auto
	3.04	10	7.4	90	1.5	183	2.0	24.6	<0.012	0.10	0.078	0.22	6,000,000	auto
	2.98	10	7.45	58	1.7	125	2.5	19.4	<0.012	0.078	0.052	0.18	3,100,000	auto
	3.52	10	7.4	57	1.4	141	1.8	13.9	<0.012	0.088	0.075	0.19	2,440,000	auto
	3.62	10	7.5	48	1.9	106	1.8	16.4	<0.012	0.072	0.056	0.14	1,745,000	auto
	3.2	10	7.5	46	1.9	84.2	0.9	23.0	<0.012	0.068	0.050	0.12	2,400,000	auto
	1.5	20	7.5	53	1.6	93.0	1.3	13.2	<0.012	0.070	0.049	0.14	510,000	auto
South St.	7.19	22	7.6	120	0.56	1130	9.4	8.53	0.015	0.58	1.72	1.6	plate wash out	comp *

* = sample not used in analysis of data

Appendix E
Results of Analyses Performed on Combined Sewer Overflows at Peoria
September 17, 1982 (Conc'd.)

Sewer	Flow (cfs)	Time interval (min)	pH	BOD_5 (mg/l)	NH_3 (mg/l)	TSS (mg/l)	Set solids (mg/l)	Vol set solids (%)	Cd (mg/l)	Cu (mg/l)	Pb (mg/l)	Zn (mg/l)	Fecal coliform (#/100 mls)	Notes
Darst St.	1.5	0	7.4	43	12.5	263	0.6	39.0	<0.012	0.090	0.26	0.43	340,000	auto
	35.1	10	7.4	500	5.6	1110	13	35.4	<0.012	0.39	0.52	1.1	2,850,000	auto
	70.72	10	7.4	320	4.1	1140	13	25.4	0.014	0.30	0.55	0.99	1,815,000	auto
	75.96	10	7.3	190	2.2	595	5.4	16.0	<0.012	0.22	0.33	0.46	2,460,000	auto
	49.28	10	7.4	190	1.8	448	5.9	16.2	<0.012	0,24	0.29	0.42	1,840,000	auto
	45.26	1	7.35	170	2.6	236	4.3	22.1	<0.012	0.25	0.12	0.44	2,300,000	auto
	21.86	10	7.4	110	3.4	501	5.0	27.7	<0.012	0.36	0.25	0.52	3,020,000	auto
	13.08	10	7.35	70	2.7	239	2.1	30.4	<0.012	0.14	0.11	0.25	4,300,000	auto
	11.61	10	7.4	100	3.6	272	4.3	28.8	<0.012	0.16	0.094	0.31	3,300,000	auto
	17.15	10	7.4	73	3.2	447	2.1	37.3	<0.012	0.14	0.098	0.26	3,170,000	auto
	19.75	10	7.2	71	3.1	203	3.0	32.7	<0.012	0.11	0.059	0.20	2,060,000	auto
	19.85	2	7.2	64	3.2	186	3.8	43.4	<0.012	0.11	0.055	0.20	3,340,000	auto
	25.89	20	7.2	53	2.8	131	2.5	23.9	<0.012	0.070	0.038	0.14	1,720,000	auto
	18.76	20	7.15	55	3.4	132	3.0	24.6	<0.012	0.068	0.038	0.20	2,460,000	auto
	5.96	20	7.3	55	4.8	110	3.0	24.5	<0.012	0.070	0.033	0.16	3,645,000	auto
	1.98	20	7.6	52	5.6	83.4	0.4	54.8	<0.012	0.078	0.031	0.12	5,500,000	auto